THE CITY OF SANTA BARBARA GENERAL PLAN

SEISMIC SAFETY – SAFETY ELEMENT

ADOPTED August 1979

Volume 6 of 6

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INTRODUCTION

GENERAL OVERVIEW AND LEGISLATION

The Seismic Safety Element, required by State law as part of the general plans for all cities and counties in California (Government Code, Section 65302f), embodies the principal geotechnical component of land use planning. Although its basic objective is to reduce loss of life, injury, damage to property, and economic and social dislocation resulting from future earthquakes, it also is concerned with slope stability problems (such as landslides) and other soil related hazards. Seismic hazards specifically to be identified and evaluated include susceptibility to surface rupturing from fault movement, ground shaking, ground failure and seismically induced waves (tsunamis or seiche). The possible impacts of soils with a high shrink-swell/creep potential, excessive erosion potential, and a high ground water level are evaluated as to their potential land use implications. Additionally, consideration is given to the risk presented by structurally unsafe buildings as they relate to earthquake safety.

The Seismic Safety Element has been prepared in two phases for the City of Santa Barbara. The first phase involved a technical evaluation of primary and secondary seismic and geologic hazards. The results of this evaluation were published in the report Geologic Hazards Evaluation of the City of Santa Barbara (Michael F. Hoover, Consulting Geologist, October, 1978). This report is included as Appendix 1, included under separate cover.

The second phase of the planning study dealt with the policy implications of the technical findings for the City. The Policy Report presents the conclusions and recommendations of this second phase, and completes the State requirements for the Seismic Safety Element for the City of Santa Barbara.

The Safety Element (Government Code, Section 65302i) is concerned with public safety related hazards, such as fire, flood, seacliff retreat, and dam safety, including their identification, mapping, evaluation, and how the hazard can be avoided or minimized in the planning process. The Open Space and Conservation Elements have significant geotechnical and safety hazard inputs also, relating particularly to mineral and soil conservation, preservation of unique geologic features, mineral resource production, and possible open space designations for areas of hazardous conditions, if warranted.

The State General Plan Guidelines (CIR, September 20, 1973) suggest combining similar elements when possible to avoid "excessive duplication" and cross references to similar or identical subjects contained in the separate elements. The approach here of combining these two similar elements is intended to provide a more comprehensive, coordinated basis for addressing and coping with major hazards and risks.

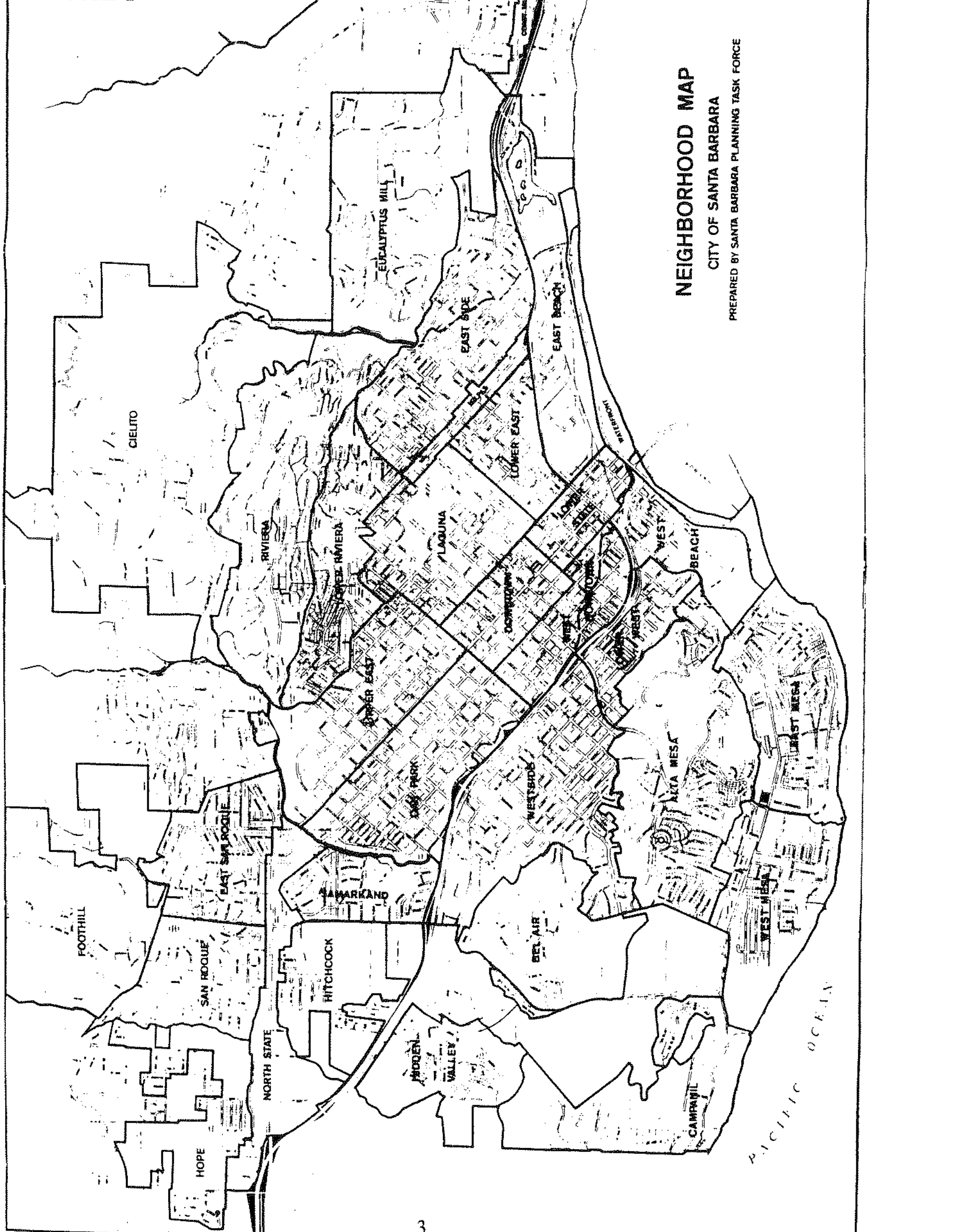
LOCATION AND AREA DESCRIPTION

The City of Santa Barbara lies in the approximate center of a narrow, 25 mile long coastal plain, about 100 miles northwest of Los Angeles. To the north of the City lies the east-west trending Santa Ynez Mountains, part of the Transverse Range geomorphical province. Santa Barbara consists primarily of a low-lying, southeastward-sloping plain surrounded on the north, west, and southwest by highlands. The lowland region, which covers an area of approximately four square miles and contains the business district and most of the residential areas of the City, is underlain by a thick series of unconsolidated sediments which range in thickness from less than one hundred feet near the margins of the plain, to several thousand feet toward the southeast. The highlands are underlain primarily by consolidated sedimentary rocks which have been uplifted along faults. These highlands range in elevation up to 600 feet along the Lavigia Hills to the southwest, 750 feet along Mission Ridge, and up to nearly 4,000 feet along the Santa Ynez Mountains, which crest just five to ten miles from the coast (Todd, 1978). Approximately 30 miles offshore to the south, the four Channel Islands, San Miguel, Santa Rosa, Santa Cruz, and Anacapa, lie parallel to the coast and serve as a barrier to heavy seas coming in from the Pacific.

Santa Barbara enjoys a mild Mediterranean climate, with mean winter daytime temperatures of 65° and a mean summer daytime temperature of 78° with cool nights, and averages 17 inches of rain per year. This temperate climate, along with the City's geographical location, majestic scenery from ocean and mountains, and a rich historical heritage are all important factors in fostering a large tourist trade and in making Santa Barbara an attractive place for people to retire.

The City of Santa Barbara has been divided into a number of distinct neighborhoods based on geographical location. These neighborhood designations have been used frequently in this report and are illustrated in Figure 1.

FIGURE 1


NEIGHBORHOOD MAP
CITY OF SANTA BARBARA
PREPARED BY SANTA BARBARA PLANNING TASK FORCE
CIELITO
EUCALYPTUS HILL
EAST SIDE
EAST BEACH
LOWER EAST
WATERFRONT
RIVIERA
LOWER RIVIERA
LAGUNA
LOWER STATE
WEST BEACH
DOWNTOWN
UPPER EAST
OAK PARK
WESTSIDE
ALTA MESA
EAST MESA
WEST MESA
EAST SAN ROQUE
SAMARKAND
FOOTHILL
SAN ROQUE
HITCHCOCK
BEL AIR
NORTH STATE
HIDDEN VALLEY
CAMPANIL
HOPE
PACIFIC OCEAN

STATEMENT OF GOALS AND PUBLIC POLICY

Goals

The goals of the Seismic Safety and Safety Element provide a link between the identified problems and issues and the policies and implementation measures which follow. They provide basic guidelines for City decisions related to natural hazards and assets as they affect land use planning and development standards. The following are recommended major goals for adoption:

To protect life, property, and public well-being from seismic and other geologic hazards.

To reduce or avoid adverse economic, social, and environmental impacts caused by geologic conditions.

Policy

The specific policies listed below provide a general direction or more specific steps for achieving the stated goals through implementation and action programs. The following are recommended policy statements:

> To maintain, revise (wherever necessary), and enforce existing standards and criteria to reduce or avoid all levels of seismic or other geologic risk.
>
> To evaluate the compatibility of existing zoning as well as future land use allocation with known geologic risk zones, or those which may be identified in the future.
>
> To recognize the need to provide greater safety for important or critical-use structures (such as hospitals, schools, public assembly facilities, dams, and utility corridors) through careful site selection, appropriately comprehensive site investigation, and enforcement of applicable codes and regulations.
>
> To prohibit development of important or critical-use structures in any active or potentially active fault zones, unless no other more suitable site can be located, and the site is shown to be safe for the intended use.
>
> To advocate improved seismic safety programs for schools and promote greater general public awareness of all types of geotechnical hazards.
>
> To improve interjurisdictional cooperation and communication, especially in regard to seismic safety aspects related to dams and reservoirs, state highway and freeway structures, regional fault studies, legislative matters, and disaster response or emergency plans.
>
> To advocate improved earthquake insurance programs.

RISK PERCEPTION

Throughout geologic time many earth processes have been at work continuously changing the earth's landscape. The term "earth processes" refers to such events as earthquakes, landslides, fires, floods, and other related phenomena. All of these processes are natural events that would occur with or without the presence of humans. When these natural processes threaten the health, safety, and welfare of man and his works, they are no longer considered to be natural processes, but are referred to as "hazards."

At the present time, it is often technically or economically infeasible to accurately predict the occurrence of a hazard or completely mitigate the impacts of a single or several cumulative hazards. By studying historical records and geologic data, however, the fact that a particular hazard exists and might occur at some time in the future in a given area can be determined with some degree of confidence. This probability of occurrence creates a risk.

The California Council on Intergovernmental Relations has separated risk into three separate categories:

1. Acceptable Risk - The level of risk below which no specific action by government is deemed necessary.

2. Unacceptable Risk - The level of risk above which specific action by government is deemed necessary to protect life and property.

3. Avoidable Risk - Risk not necessary to take because individual or public goals can be achieved at the same or less total "cost" by other means without taking the risk.

The concept of acceptable risk may seem difficult to comprehend at first, but this type of risk is actually a part of everyday life. Almost all activities have some degree of risk associated with them, and natural and artificially induced hazards of some degree and kind are almost always present. Efforts can be taken, however, to reduce the consequences of known hazards and associated risks.

It must then be asked "how safe is safe enough?" There is no uniform level of risk that is acceptable to the general public, and maximum safety would be desirable. Minimizing risks, however, usually involves practices that result in higher costs. The cost of providing protection from a hazard increases proportionately with the level of risk reduction required and severity of the hazard. The cost of each additional increment of protection becomes increasingly more and more expensive, until at some point, the cost of providing protection becomes prohibitive when compared to the benefits derived. At this point, the risk becomes acceptable, or the public is no longer willing to pay more to further reduce the risk. The decision of when an acceptable level of protection is reached must ultimately be decided upon by the public.

Criteria for Decision-Making Related to Risk: The following factors should be considered in evaluating risk:

1. Severity of potential losses - Seismic or other natural hazard impacts including loss of life, injury, property damage, and loss of function should be considered.

2. Risk reduction capabilities - Consideration should be given to current technological capabilities, available fiscal and manpower resources, and established priorities.

3. Probability of loss - The probability of future seismic or other adverse hazardous natural occurrences should be evaluated in light of their possible effect on structures or human activities.

4. Adequacy of basic data - This is an important factor in estimating the probability of unperceived hazards.

For the most part, there must be reliance upon only very general, qualitative appraisals of these factors, considering the present scope of study.

RELATIONSHIP TO OTHER GENERAL PLAN ELEMENTS

The technical data compiled in the preparation of the Seismic Safety and Safety Elements and the technical Geologic Report can be utilized by planners engaged in the planning process. While the data is tentative in some respects, the findings and conclusions of the two Elements should be reflected in the regulations and controls placed on development within the City.

Because the Seismic Safety and Safety Elements are two of the last of the required General Plan Elements to be prepared by the City, some of the information and implications developed within the Elements may not have been fully considered in the preparation of other General Plan Elements. Three General Plan Elements in particular should be reviewed to assure that each reflects the findings and recommendations of the Seismic Safety and Safety Elements. These three Elements are: Land Use, Circulation, and Open Space.

Land Use Element

Land use patterns within the City of Santa Barbara are well established, and the Land Use Element largely reflects the existing land use pattern within the community. For this reason no <u>substantial change</u> in land use is considered possible or required for reasonable public safety at this time. However, the Land Use Map should be reviewed and modified in response to the Seismic Safety and Safety Element's findings, particularly the location of fault traces, landslide, liquefaction, fire, or flooding.

The objectives in applying the knowledge gained in the course of the two Elements should be to reduce the risk to life, reduce the probability of property loss, and ensure that critical public facilities can continue to function after major natural disasters.

Circulation Element

The circulation network of the City of Santa Barbara is well established, and the Circulation Element of the City largely reflects the existing condition. Major new circulation facilities are not proposed as part of the Circulation Element.

The circulation network could be substantially impacted by a moderate-to-large earthquake. The primary impact would be possible damage to the various overcrossings and undercrossings within the City and problems resulting from landslides within the foothill regions. Any modification of existing circulation facilities, particularly modification at any crossing structure, should reflect the most current seismic data and construction requirements. Any new construction should utilize the most up-to-date seismic response design criteria appropriate.

Open Space Element The Open Space Element, by its very nature, can be used effectively to reduce public risk from identified natural hazards. By the use of open space land use designations and zoning for low-intensity uses in hazard areas, potential loss of life and property damage can be avoided.

The Open Space Element of the City should be reviewed to assure that full use of this valuable planning tool is used, and where possible, to enhance both the aesthetic as well as the public safety aspects of the community's development.

CURRENT HAZARD REDUCTION PROGRAMS

Geologic Hazards Building safety and construction in the City of Santa Barbara are regulated by the requirements set forth in the 1976 Edition of the Uniform Building Code (UBC). These building code requirements were adopted and appended to the Municipal Code of the City of Santa Barbara in 1977. The UBC represents the current state of the art in building safety and the construction of earthquake-resistant structures.

At his discretion, the City Building Official, under the Geologic Hazards section (Article 44) of Ordinance 3905 may require that as a prerequisite to the granting of a building permit, the following amendments or modifications to the UBC be required to prevent "slippage, subsidence or other movement of soil or rock, either during construction or at a later time."

1. An engineering geological report by a recognized engineering geologist. The report shall include a description of the on-site geology, and make recommendations and conclusions regarding the effect of the geological conditions on the proposed construction (i.e., ground-shaking severity from earthquakes, ground rupture from fault displacement, potential for liquefaction or landslides, the effects of high groundwater, settling rates from compressible soils, etc.).

2. A soils report prepared by a civil engineer who is licensed by the State of California and experienced in the field of soil mechanics. The report shall include data regarding the nature, distribution and strength of existing soils, and recommendations for grading procedures and design criteria for corrective measures.

3. Building plans and specifications prepared by a registered architect, civil or structural engineer to eliminate the danger of structural damage. These plans shall be based on the recommendations contained in the soils and engineering report.

Additional recommendations made by the Building Official shall also be incorporated into the grading and engineering plans. The Building Official may also require additional supplemental reports, and all reports are subject to his approval.

Included in the UBC are provisions for the abatement of unsafe buildings and building appendages such as parapets, cornices, spires, towers, tanks, etc. Current policy is to abate these hazards when they are identified. Historic buildings located within El Pueblo Viejo (the historic district located in the Downtown area) and various other locations throughout the rest of the City are subject to the Building Safety Codes for Historic Buildings as outlined in the UBC. To reduce the risk associated with the use of existing hazardous buildings, City policy prohibits the use of these structures for assembly type occupancy. Hazardous structures may have their maximum occupancy permits reduced by the Division of Land Use Controls.

The City of Santa Barbara, in its Municipal Code, has adopted the provisions of the Subdivision Map Act of the State of California. This act concerns itself basically with the procedures and requirements for recording subdivision maps, lot design, and physical improvements associated with the creation of lots. This act requires that soils reports be made before subdivisions are approved, unless the requirement is waived by local government. The Building Official has the authority to enforce the provisions of the Subdivision Map Act.

In the event of an impending tsunami striking the Santa Barbara coastline, coordination of warning and evacuation operations is conducted by the City Office of Emergency Services. Procedures for all phases of a tsunami hazard alert (advisory, warning, and recovery operations) have been outlined in advance in the Tsunami section of the City of Santa Barbara Natural Disaster Plan.

Flooding Hazards

The City of Santa Barbara recently approved an ordinance adopting the regulations relating to flood plain management and the implementation of the National Federal Flood Insurance Act of 1968. This ordinance prohibits construction of any structure within the 100-year flood plain (as identified by "The Flood Insurance Study for the City of Santa Barbara," May 4, 1978) without full compliance with the regulations set forth in the ordinance. The complete text of the ordinance is included in Appendix 2.

The purpose of the Flood Plain Management Ordinance is to "promote the public health, safety and general welfare, and to minimize public and private losses" due to flood conditions in specific areas by provisions designed to:

1. Protect human life and health;

2. Minimize expenditure of public money for costly flood control projects;

3. Minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public;

4. Minimize prolonged business interruptions;

5. Minimize damage to public facilities and utilities such as water and gas mains, electric, telephone and sewer lines, streets and bridges located in areas of special flood hazard;

6. Help maintain a stable tax base by providing for the second use and development of areas of special flood hazard so as to minimize future flood blight areas;

7. Ensure that potential buyers are notified that property is in an area of special flood hazard; and

8. Ensure that those who occupy the areas of special flood hazard assume responsibility for their actions.

An additional proposed flood control ordinance currently in the review process is the "Creek Setback" ordinance. In short, the Creek Setback ordinance would prohibit development not approved by the Building Official and Zoning Officer or the Planning Commission within the designated distances from a creek bank.

The purpose of this legislation is to prevent undue damage or destruction of future developments, prevent the development of structures that could increase the severity of downstream flooding, and to protect the health safety, and welfare of the general public.

Fire Hazard

In the City of Santa Barbara it is required that on vacant land all flammable brush, grass, weeds, etc., be completely removed from properties less than one acre in size. Larger parcels shall have the hazard reduced by construction of 30-foot fire breaks around the perimeter, and in one-acre sections throughout the property. Properties such as hillsides that have erosion problems may reduce the hazard by selective thinning of vegetation or other methods approved by the Fire Prevention Bureau.

Special provisions have been adopted that must be complied with within the boundaries of areas designated as High Fire Hazard Zones:

1. Maintain an effective fire break by removing and clearing all flammable vegetation for a distance of at least 30 feet from all structures. If the Building Official or City Fire Chief finds that because of extra hazardous conditions a fire break of only 30 feet is not sufficient to provide a reasonable amount of protection, he may require a break of up to 100 feet from any structure. Root systems required for soil stabilization may be left as long as they do not provide a means for rapidly transmitting flames to the structure.

For new construction, or the expansion of existing facilities, the following is required:

2. Fire retardant roof materials.

3. Fire resistive exterior walls.

4. Fire resistive materials or design for decks, balconies, roof overhangs, attached patio covers, and similar architectural features that project more than six feet from exterior walls.

5. Restrictions on attic ventilation openings or ventilation louvers in eaves, overhangs, between rafters, at eaves, or other overhang areas.

6. Spark arrestors on fire pits, fireplaces, or appliances burning liquid or solid fuels.

The Santa Barbara South Coast Red Flag Fire Alert plan involves cooperative effort between the fire departments of the County and City of Santa Barbara; the fire protection districts of Montecito, Carpinteria, and Summerland; the Santa Barbara County Sheriff's Department; and the U.S. Forest Service. The objective of this program is to unite fire and law enforcement agencies protecting the south coast of Santa Barbara County to prevent future fires. The basis of the plan lies in a procedure whereby the risk of fire is lessened by placing restrictions on public activity and entry in designated areas during critical weather conditions. In addition, it calls for assistance from individuals and organizations outside the fire service to help alert the citizenry to the dangerous fire potential.

The City is currently in the preparation stages of its Fire Master Plan. The goal of this plan is to provide a cost-effective fire protection system adequate to determine and meet community needs. This plan will review and make recommendations in regard to the Prevention, Suppression, Emergency Services, and Administration phases of the City fire protection system. The recommendation made in this element should be reviewed and amended as necessary upon the adoption of the Fire Master Plan.

HISTORICAL GEOLOGY AND SEISMIC HISTORY

Through almost all of its recent geologic history, the Santa Barbara area has been under the ocean, receiving sediments shed from continental areas to the east. These sediments, now consolidated, form the thick series of sandstones and shales that are presently exposed in the Santa Ynez Mountains.

In Pliocene times, nearly twelve million years ago, these sandstones and shales were uplifted, warped, and tilted to form the Santa Ynez Mountains and the South Coast region. Along the coast, however, faulting resulted in subsidence of some areas. These subsiding areas, including the Santa Barbara basin, became traps for material eroded from the mountains.

Pleistocene and recent times (from two million years ago to the present) have been marked by continued uplift and erosion of the Santa Ynez mountains, accompanied by local faulting and uneven deposition and erosion in the coastal area. Faulting has resulted in uplift of the Hope Ranch hills, the Mesa, and Mission Ridge, with a smaller relative uplift in the San Roque area. The Santa Barbara plain has also experienced uplift, resulting in emergences from the sea. However, uplift here has occurred to a lesser degree than surrounding areas, so that the Santa Barbara plain remains a structural and physiographic basin.

Pleistocene deposition resulted in the building of alluvial fans along the base of the Santa Ynez Range. At present, these fans are being trenched by streams, and deposition is occurring primarily in lower valley areas and along larger streams (Todd, 1978).

Historically there is good record of strong earthquakes affecting Santa Barbara, starting in 1806, when the walls of Mission Santa Barbara were cracked by a large earthquake. Santa Barbara was severely shaken again on December 12, 1812. The Royal Presidio, the Mission, and many adobe buildings experienced severe damage or were destroyed. This shock is believed to be one of California's strongest earthquakes in history. Epicentered somewhere in the Santa Barbara Channel, the shock was reported to have generated tsunami waves perhaps 50 feet high.

A period of quiescence followed the shock of 1812, with only minor tremors reported in 1815 and 1816. In 1852, an earthquake shook the region severely, but with no reported damage.

In 1857 the earliest of California's three great earthquakes occurred (the others were 1872 and 1906). Known as the Fort Tejon earthquake of 1857, it is estimated to have had a Richter magnitude of 8.3. The effects of the earthquake were widespread in Santa Barbara, with damage to adobe structures, reports of rocks rolling down hills, and water being spilled out of the Mission reservoir.

For the next 63 years, Santa Barbara enjoyed a period of relative calm. From 1857 to 1925, 37 moderate tremors were felt, with the strongest of these occurring in 1872, 1893, 1902, and 1917. This peace was shattered on June 29, 1925, at 6:43 a.m., when Santa Barbara suffered its worst natural disaster.

Although the Richter magnitude scale was not developed until 1935, comparison records show that the main shock had an approximate magnitude of 6.3 (Olsen and Sylvester, 1975). Foreshocks, or small tremors that precede a major shock, were known to start by City water pressure gauges as early as 3:27 a.m., local time. By the morning of July 5, only seven days after the main shock, 264 aftershocks were recorded, and they continued on into September of that year (Willis, 1925). Because of inadequate records, it is impossible to locate the epicenter of the earthquake any closer than perhaps somewhere in the Santa Barbara Channel area (Olsen and Sylvester, 1975).

Eyewitness accounts of the earthquake attest to the severity of the event; the Reverend A. Hobrecht, Father Superior of the Mission, wrote:

> *"The writer was in the choir loft of the church, when on June 29, 1925, the earth began to rock beginning with a thump that seemed to come from a subterranean explosion, the earthquake shook those mighty walls and made them sway, as it appeared, several feet beyond the perpendicular. The noise was deafening. Subsiding for what seemed a brief second, the rocking began anew with greater violence, so that I expected to see the building crumble any moment."*
>
> *"Scarcely had we reached the open air, when the earth began to rock and we had to run from falling stones that dropped from the towers." (Hobrecht, 1925)*

Thirteen people lost their lives during the earthquake, and over 180 buildings were destroyed or seriously damaged.

The amplifying effect that saturated soils can have on the severity of ground shaking was clearly demonstrated. The most severe damage to structures and pavements occurred along the beachfront and in the downtown areas that had been constructed over poorly consolidated artificial fill. Movement of this unstable ground resulted in ground settlements of up to 10 inches, cracks in sidewalks that ranged from 10 inches to 200 feet, and 820 feet of the sewer outfall pipe was found to be out of grade as much as 15 inches.

The shock also resulted in the failure of the Sheffield Dam, a 25-foot-high, 800-foot-long earth fill dam located at the head of Sycamore Canyon. After examination by several prominent engineers it was concluded that the base of the dam had become saturated, and the shock had opened up vertical fissures from the base of the dam to the top; the water rushing through these fissures simply floated the dam out in sections (Nunn, 1925). This resulted in the inundation of the unoccupied Sycamore Canyon.

Earthquakes continued to plague Santa Barbara in 1926. On February 18, a strong shock, presumably epicentered offshore, was felt rather strongly along much of the coast. Exactly one year after the June 29, 1925 earthquake, a strong aftershock caused some damage at Santa Barbara, and resulted in one death due to a falling chimney.

On November 4, 1927, a major (7.3 magnitude) earthquake occurred off Point Arguello. This quake generated a small tsunami that reached a height of about six feet at Santa Barbara. On June 30, 1941, a 5.9 magnitude earthquake epicentered offshore near Carpinteria caused $100,000 damage at Santa Barbara, especially to buildings damaged in 1925 and imperfectly repaired (Sherburne, 1975).

On July 21, 1952, an earthquake on the White Wolf fault in Kern County shook Santa Barbara. This 7.7 magnitude quake seriously damaged structures on State Street, many of which had been damaged in 1925 and 1941.

During the summer of 1968, an earthquake swarm or a sequence of earthquakes which are temporarily and spatially related, without an earthquake of outstanding magnitude, occurred in the east part of the Santa Barbara Channel. The swarm consisted of 63 shocks, the largest of which was a 5.2 magnitude quake on July 4. Twenty-two shocks in all were felt in the Santa Barbara/Goleta area. An estimated $12,000 in damages were caused by three earthquakes with magnitudes greater than 4.2 (Olsen and Sylvester, 1975).

The last major earthquake to affect Santa Barbara occurred recently, on August 13, 1978. The earthquake was measured as a 5.1 magnitude earthquake at the California Institute of Technology, and a 5.7 magnitude at Berkeley.

Santa Barbara withstood the tremor rather well, sustaining $136,000 in damages, $40,000 of which were produced at Marina I in the Harbor, and $25,000 at the Municipal Airport. Total estimates of damages caused by the earthquake were $9.26 million to the public sector ($7.75 million of that occurred at the University of California) and $2.36 million to the private sector. The most serious damage experienced in the private sector occurred in mobile home parks where inadequate bracing against lateral forces caused many mobile homes to fall off their foundations.

Figure 2 graphically illustrates the approximate epicenter of major historical earthquakes in the Santa Barbara region.

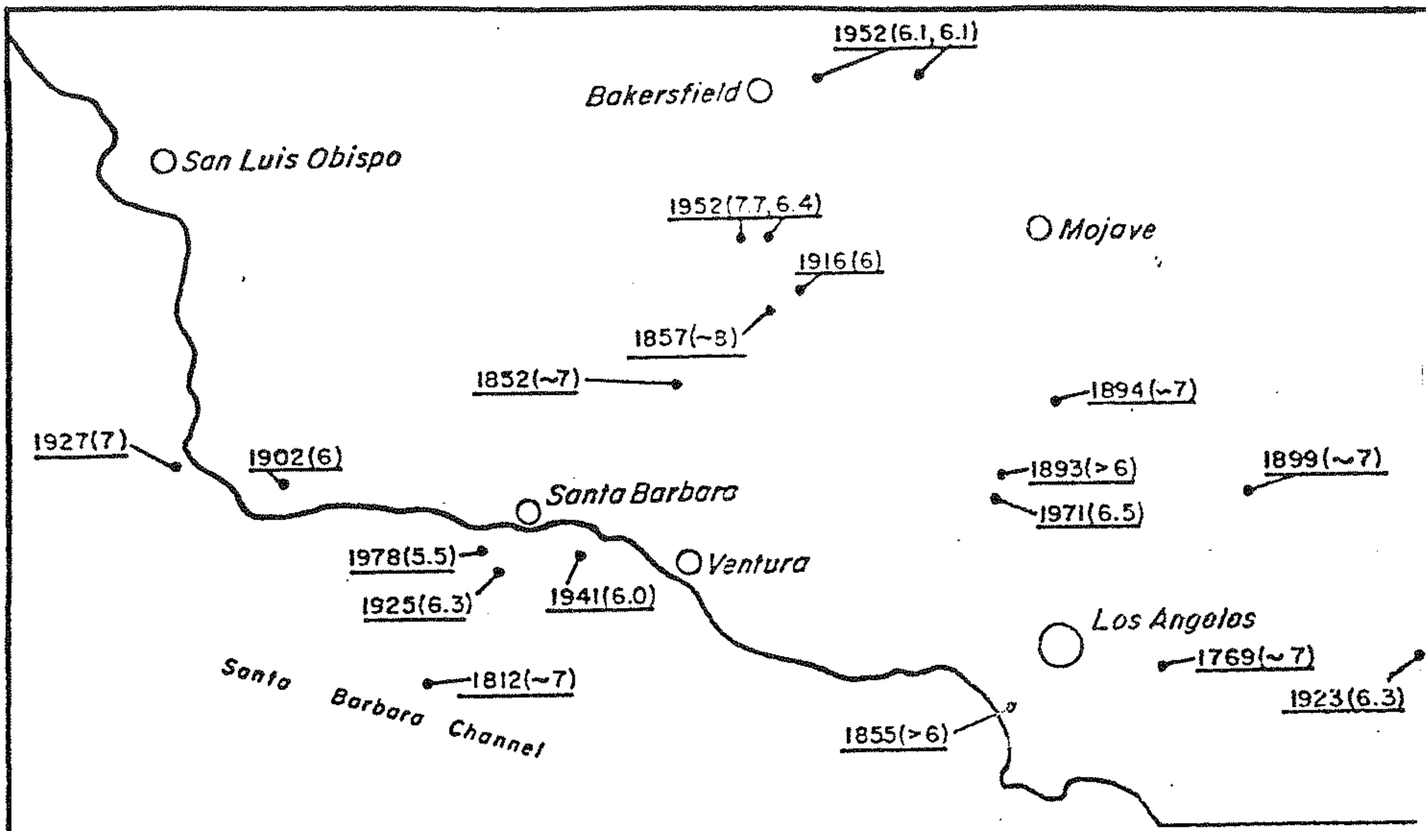
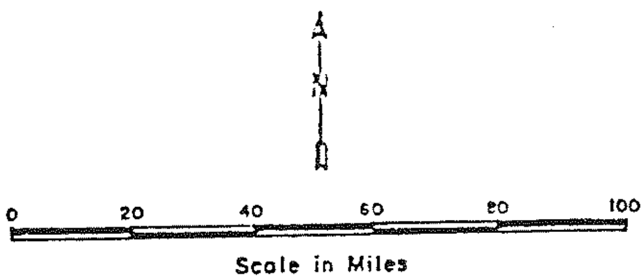


Figure 2

MAJOR HISTORICAL EARTHQUAKES
IN THE SANTA BARBARA REGION



PRE 1933 LOCATIONS AND MAGNITUDES HAVE BEEN
ESTIMATED FROM HISTORICAL RECORDS AND ACCOUNTS

From: Hoover, 1978.

INVENTORY OF LOCAL FAULTING

The text of this discussion is from Hoover, 1978. For purposes of this study, the classification of faults will be that devised by the Division of Mines and Geology:

Historically Active - Faults on which earthquakes have occurred during historic time (200 years) are classified as historically active. Often it is hard to pinpoint the exact fault responsible for an earthquake, as epicenters are not always well located, and fault patterns are often complex.

Active - Faults that show evidence of displacement during the most recent epoch of geologic time, the Holocene, are classified as active. The Holocene epoch is usually considered to have begun 11,000 years ago. It is considered that any topographic expression of movement along the fault is evidence that the fault is active, because after 11,000 years, such evidence would probably be erased by erosion and deposition.

Potentially Active - Faults which displace deposits of Pleistocene age but show no evidence of movement in the Holocene period can be considered to be potentially active. Pleistocene time is generally held to be the last 2-3 million years. (See: Geologic Time Scale, Appendix #4.)

Inactive - Faults that displace rocks of early Pleistocene age or older and show no more evidence of recent movement are classified as inactive.

The local faults identified are as follows:

Mesa Fault

The Mesa fault forms the uplifted "La Mesa" between the harbor and Arroyo Burro Creek. The fault generally parallels Modoc Road and San Andres Street. The fault is not clearly exposed; however, its location has been inferred, on the basis of water well data and rock exposures in the western portion of the City. In the south downtown area, the fault location is inferred on the basis of possible fault line features that include recurrent sidewalk and street damage, historic hot springs, reported railroad track displacement, and small anomalous topographic mounds or possible scarps.

The Mesa fault can be traced southeastward from its intersection with the More Ranch and Mission Ridge faults for about four miles. It is inferred that the fault extends into the sea slightly south of Stearns Wharf, near the Veterans Hall. At this location the railroad tracks were reportedly severed during the 1925 earthquake (P. Olsen, personal communication, 1978). Recent investigations (Muir, personal communication, 1978) indicate that the Mesa fault joins the Offshore Barrier fault (Muir, 1968), and eventually joins the Rincon Creek fault in Carpinteria.

There is no conclusive evidence that the Mesa fault is active. Professor A.G. Sylvester of the University of California, Santa Barbara, has established a series of precise level lines across the fault. The level line data indicates no vertical movement or creep has occurred in the past eight years (A.G. Sylvester, personal communication, 1978). Unfortunately the fault has not been exposed in exploratory trenches, so it cannot be demonstrated that Holocene soils have been offset by the fault.

Overall, the Mesa fault is considered potentially active, exhibiting some characteristics of activity such as curb push-outs, possible railroad track displacement, and so on.

No seismic events have been instrumentally recorded on the Mesa fault. The 1925, 1941, and 1978 earthquakes, however, occurred on active offshore fault(s) (probably the Red Mountain and/or Pitas Point faults), and offshore geologic data suggest a structural relationship between the Red Mountain fault and the Mesa/Rincon Creek fault (Geotechnical Consultants, 1974a). The Mesa fault is therefore considered capable, according to Atomic Energy Commission standards. Future movement on the Mesa fault is expected to be sympathetically related to a major event on the Red Mountain Thrust, rather than generated from the Mesa fault itself.

Mission Ridge Fault

The Mission Ridge fault trends east-west across the northern portion of the City. The fault forms a series of hills including those east of Sycamore Canyon, the north side of Mission Ridge, and the small mesa south of State Street between De la Vina Street and Hitchcock Way.

Although not well exposed, the eastern extension of the fault is believed to join the Arroyo Parida fault in Montecito. The western portion is covered by alluvium. It is uncertain whether the Mission Ridge terminates at the juncture of the Mesa-More Ranch-Mission Ranch fault or is continuous as the More Ranch fault.

No seismic events are instrumentally attributable to the Mission Ridge fault. Trenching across a branch of the fault demonstrated that it was active during or after the late Pleistocene (last 500,000 years) but did not demonstrate any Holocene movement (last 11,000 years). Trenches across the Arroyo Parida fault (an extension of the Mission Ridge fault) indicate late Pleistocene movement. Holocene movement may have occurred, but cannot be determined without more sophisticated dating of trench samples. The Mission Ridge fault is considered potentially active; however, additional investigations are recommended along the eastern extent to determine if this portion of the fault is more active.

Lavigia Fault

The Lavigia fault can be traced interruptedly across the City for approximately 3.5 miles. It emerges in the Hope Ranch area, crosses the Mesa, and extends out to sea near Santa Barbara Point. The fault is overlain by terrace deposits from La Vista del Oceano to the seacliff; its location here has been determined by subsurface data (Herron, 1975).

Based on seacliff exposures near the point, the Lavigia fault is inferred to dip to the southwest at 75° or steeper. This may not be the main trace of the fault, but exposures to the north do not adequately delineate any others.

The best evidence of displacement on the Lavigia is near Veronica Springs. Here Miocene shales are upthrown on the south side of the fault and a sequence of Pleistocene Santa Barbara Formation is downthrown on the north. Water well data in this area indicate minimum vertical displacement of 600 feet. This displacement may attenuate toward the east, where the strain may be absorbed by the numerous folds from Arroyo Burro to Santa Barbara Point. The Lavigia fault is considered potentially active since it displaces Plio-Pleistocene sediments.

Lagoon Fault

The Lagoon fault lies at the base of the south-facing hill between the Montecito Country Club and Sycamore Canyon. This east-west trending fault displaces Miocene shale on the north, again Pleistocene fanglomerate to the south. An exploratory trench at the north end of Lou Dillon Lane exposed the Monterey Shale in fault contact with the fanglomerate (R. Courdray, personal communication, 1978). The fault is reported to dip to the south at approximately 60 (T.L. Bailey, written communication, 1977). The Lagoon fault is considered potentially active since it displaces late Pleistocene fanglomerate.

Sycamore Fault

The Sycamore fault can be traced nearly three miles, from approximately 4,500 feet east of Sycamore Canyon where it may intersect the Montecito fault, to Mountain Drive where it is apparently truncated by the Mission Ridge fault. Although investigators have mapped the Sycamore fault northwestward through the San Roque district (Herron, 1974), this study revealed no conclusive evidence that the fault extends west of Mountain Drive.

The south-dipping, south side down Sycamore fault juxtaposes Miocene Monterey Shale with Pleistocene fanglomerate on the south side of Mission Ridge. The fault can be traced as a formational contact across the south side of Mission Ridge and is well exposed on Mission Ridge Road in the Franceschi area. Springs on Tremonto Road near Mountain Drive mark the apparent trace of the fault where it intersects the Mission Ridge fault.

The Sycamore fault is considered potentially active since it offsets late Pleistocene fanglomerate.

Montecito Fault

The Montecito fault was first mapped in 1933 by Bailey. He called it the Eucalyptus Hill fault. It was mapped generally as shown on Plate 1. An eastward extension of the fault was first suggested by Geotechnical Consultants, Inc. in 1974, and the entire fault was renamed the Montecito fault. Recent geologic investigations in eastern Santa Barbara indicate a fault system with the same alignment as the Montecito fault. As a result, we have extended the Montecito fault northwest of Bailey's mapping.

The Montecito fault system is most evident on Chase Drive, where Miocene Monterey Shale is exposed north of the fault and Pleistocene fanglomerate to the south. Fault plane attitudes indicate a slight dip of 85°.

The fault can be traced inside the City for approximately 2.2 miles, apparently terminating against the Mission Ridge fault atop Mission Ridge. The length of the fault is approximately six miles, with the eastern trace terminating against the Arroyo Parida fault east of Montecito.

The Montecito fault is considered potentially active since it offsets late Pleistocene fanglomerate. Moreover, exploratory trenches along a small branch fault of the Montecito or Sycamore fault suggest even more recent movement.

Additional trenching and dating are recommended to further evaluate this fault's activity.

Eucalyptus Hill Fault The Eucalyptus Hill fault can be traced for approximately 1.5 miles within the northeast corner of the City, where it extends from Montecito under the deep alluvial cover along Camino Vieja. The fault is exposed in the hillsides on either side of Barker Pass Road. Exploratory trenches on both sides of the road exposed two possible branches of the fault (D. Weaver and R. Coudray, personal communication, 1978). The southern branch apparently turns northwest and crosses Sycamore Canyon near Ranchito Road.

Total displacement on the fault is unknown, although water well data (near Woodley and Sycamore Canyon Roads) indicated a minimum vertical displacement of approximately 400 feet. The youngest rocks known to be displaced are Pleistocene fanglomerates. The fault is therefore considered potentially active.

More Ranch Fault The More Ranch fault trends east-west for nine miles by the south coast of Goleta, near the Santa Barbara Municipal Airport. The eastern end of the fault curves and may continue east as the Mission Ridge fault (Dibblee, 1966). The late Pliocene to Pleistocene sediments north of the fault have been downdropped as much as 2,000 feet near the ocean; Dibblee's (1966) map indicates displacement of recent alluvium as well as old alluvium. Geologically recent movement is suggested by the north-facing scarp which bounds the north edge of the coastal mesa at the east end and a small north-facing scarp near the coast at the west end of the fault (Dibblee, 1966). This fault is therefore considered to be active (Santa Barbara County Seismic Safety Element, 1978).

In addition to the above faults, numerous unnamed faults are located in the City, primarily in the Mission Ridge and Sycamore Canyon areas. These faults are shown on the Geologic Map.

Summary The More Ranch fault is the only active fault within the City of Santa Barbara. By definition, active faults have surface displacement within the past 11,000 years (California Division of Mines and Geology). As mentioned above, the Mesa fault exhibits some characteristics of an active fault (fault line fractures and tectonic relationship to active offshore faults); it is therefore considered a capable fault.

Because of their proximity to the City, the most critical faults in the Santa Barbara area are those that pass through or near the City itself: the Lavigia, the Mesa, the More Ranch, and the offshore Red Mountain Thrust. Earthquakes on larger more distant faults would attenuate (lose energy) by the time they reached Santa Barbara and thus are not controlling events.

Determination of seismic potential on the local faults is related to regional tectonics. The Mesa and Lavigia faults are reportedly secondary faults that converge at depth with the active Red Mountain Thrust, an offshore north-dipping fault. Thus the Mesa and Lavigia may not have the capacity to generate an earthquake, but would provide conduits for seismic energy generated from the Red Mountain Thrust (causative fault). This type of fault movement is termed sympathetic rather than generative. Thus, the Red Mountain Thrust is a more significant fault than the onshore Mesa or Lavigia faults. An additional complication is that the Mission Ridge and More Ranch faults may be connected to a more extensive series of related faults. Further work is required to determine the activity and significance on the Mission Ridge/Arroyo Parida and the More Ranch faults. For our analysis, the Mission Ridge is considered connected to the Arroyo Parida for 21 miles. The More Ranch is thought to be en echelon with the Red Mountain and extending to Gaviota. The More Ranch fault may be capable of generating a seismic event, but it is not as long as the Red Mountain; thus the Red Mountain...is used in constructing a design earthquake.

HAZARD IDENTIFICATION AND REDUCTION

The following discussion will describe the various seismic and geologic hazards identified in the City of Santa Barbara. Included in each subsection will be a general description of the hazard, local conditions where applicable, possible effects of the hazard, and recommendations for hazard reduction. The discussion has been organized to first identify seismic-related hazards (i.e., ground displacement, ground shaking, liquefaction, tsunamis, seiche, and structural hazards), and secondly, general geologic hazards (landslides, high groundwater, expansive soils/soil creep, and erosion).

Ground Displacement

General Description

Ground surface displacement along a fault, although more limited in area than the ground shaking associated with it, can have disastrous consequences when structures are located straddling the fault or near the fault zone. Fault displacement involves forces so great that it is not practically feasible (structurally or economically) to design and build structures to accommodate rapid displacement and remain intact. Amounts of movement during a single earthquake can range from several inches to tens of feet.

Another aspect of fault displacement comes not from the violent movement associated with earthquakes, but the barely perceptible movement along a fault called "fault creep." Damage by fault creep is usually expressed by the rupture or bending of buildings, fences, railroads, streets, pipelines, curbs, and other such linear features.

Whether by rapid movement or slow creep, cumulative amounts of displacement along a fault can be quite significant. In the last 40 million years, the San Andreas fault in southern California has moved approximately 130 to 180 miles.

Local Conditions

The local faults within the Santa Barbara area have been identified in the previous section "Inventory of Local Faulting." No definitive analysis has been prepared as to the ground displacement potential of any of the faults discussed. For purposes of this study, any fault identified as active or potentially active should be evaluated as to its ground displacement potential prior to consideration for development.

Effects of the Hazard

Permanent effects of ground displacement include: abrupt evaluation changes (up or down) of the ground surface elevation along the fault; alteration of surface drainage, changes in groundwater levels in wells; and dislocations of street alignments and property lines.

Secondary effects of ground displacement could include: disruption of traffic and emergency vehicles due to road and bridge destruction; flooding due to the disruption of surface drainage; and the disruption of vital utilities and community services.

Hazard Reduction

The only reasonable method of mitigating a ground displacement hazard is to avoid placing structures across faults that are capable of moving. If an active fault is found to be located beneath an existing structure, little can be done to protect that structure short of actually moving it to a less hazardous location. Often linear features such as roads, pipelines, utility lines, etc., must cross faults. In this case, provisions should be made in advance for back-up systems, emergency cut-off valves, and rapid repair of damage if fault movement were to occur.

Recommendations

1. Additional geologic studies should be performed on the Mesa, Mission Ridge, and Lavigia faults to determine whether these faults should be considered active and to define further the width of the fault zones. Until such studies are completed, individual studies prepared by an engineering geologist shall be made for all major new structures proposed on faults or in fault zones identified by this report.

2. Additional geologic investigations of the More Ranch fault should be conducted to determine the extent of the fault activity and determine its precise location.

3. The Mesa, Mission Ridge, and Lavigia faults shall be considered as potentially active, unless detailed seismic-geologic investigations confirm the contrary. All other faults shall be considered as potentially hazardous and subject to further geologic investigation prior to development.

4. A geologic investigation is recommended specifically for the vicinity of Sheffield Reservoir, to determine if a branch of the Mission Ridge fault trends through the reservoir or its abutments.

5. Santa Barbara should encourage the performance of regional and local geologic-seismic investigations by qualified federal and state agencies, universities, and private consultants.

6. Buildings shall not be allowed to be constructed over an identified active fault. Appropriate setback requirements shall be determined by a registered engineering geologist based upon the specific site conditions involved.

Ground Shaking

General Description

In California, the largest losses of life and property due to a geologic hazard will be caused by ground shaking in response to movement along a fault. Since 1912, a total of 26 damaging earthquakes have occurred in California, resulting in 1,020 lives lost, and over seven billion dollars in property damage when measured in 1971 dollars (California Division of Mines and Geology, 1973). Most of these losses can be directly attributed to the effects of ground shaking. By the year 2000, if present earthquake safety practices remain unchanged within the State, earthquake shaking stands to be a 21-billion-dollar problem (CDMB, 1973).

Ground shaking, what most people and structures react to during an earthquake, is unfortunately one of the most difficult seismic hazards to predict and quantify. The extent and severity of ground shaking at a particular site is controlled by many factors. Listed below are some of these factors.

1. Earthquake Magnitude - Commonly measured on the Richter Scale. This is an arbitrary measurement of the total amount of energy released by an earthquake.

2. Maximum Ground Acceleration - The speed which the ground moves measured in "g's." A vertical ground acceleration of 1.0 g will throw loose objects into the air.

3. Near Surface Amplification - The presence of soils above bedrock can have an amplifying effect on earthquake shock waves. Ground shaking is usually most severe on thick, water saturated, unconsolidated sediments, and less severe on solid bedrock.

4. Distance from Epicenter - As earthquake shock waves move through the ground, they alternate or lose energy. Over long distances this loss of energy can be significant.

5. Duration of Strong Shaking - How long ground shaking continues plays a major role in determining the amount and extent of structural damages during an earthquake.

6. Fundamental Periods - Every structure has its own fundamental period or natural vibration period. If the natural vibrations of ground shaking coincide with the natural vibration period of a structure, structural damage can be greatly increased.

The largest magnitude earthquake that could be expected on an active or potentially active fault may be determined empirically by using total fault length (Greensfelder, 1973). Based on the work of Albee and Smith (1966) and Bonilla and Buchanan (1971), the maximum credible earthquake is defined as the event that would occur if 50% of the fault length ruptured. A more realistic design earthquake, one with a greater degree of recurrence, assumes that 25% of the fault length would rupture (Hoover, 1978).

The extent of damage suffered during an earthquake can also depend on non-geologic factors. The type of building and its structural integrity can dictate the severity and extent of the damage suffered. After Santa Barbara's most destructive earthquake in 1925, a committee of structural engineers reported, "It was unanimously agreed that wherever good materials have been properly used and the design an intelligent one, slight or no damage has resulted." (Engineering Committee Report, 1925).

Assessing the ground shaking hazard for various types of structures is difficult because of the great variety of structures involved. Nevertheless, three general categories have been developed:

1. Less than four-story structures.
2. New, large structures.
3. Old, large structures.

Under most conditions, the less than four-story structures tend to survive quite well. The new, larger structures refer to those built according to normal standards but without any special design. Various engineering methods can alter the characteristics of buildings, however, so that these structures will serve as satisfactorily as smaller ones. The category of old, large structures covers buildings erected by methods today considered substandard. These buildings may have been weakened by previous earthquakes and thus be more susceptible to damage than newer structures (Hoover, 1979).

The type of building materials used in construction can also dictate building performance in earthquakes. Generally, small one, two, and three story wood-and-steel frame buildings have performed well in earthquakes due to their light weight and flexibility. Reinforced concrete structures will also usually perform well. Buildings constructed from inflexible materials, such as unreinforced brick and concrete, hollow concrete block and clay tile, and adobe, are more vulnerable to earthquake damage.

It is economically infeasible, using the present state-of-the-art construction techniques, to build a totally earthquake-proof structure; therefore, a certain amount of risk must be accepted when using current building methods. It is possible, however, to reduce this risk to an acceptable level and build earthquake-resistant structures that will not pose a collapse or loss of function hazard in strong earthquakes. A more complete discussion of building types and their relative safety during earthquakes is included in the "Structural Hazards" Section.

Effects of the Hazard

The primary effect of ground shaking is the damage or destruction of buildings and infrastructures, and thus, the potential for loss of life. Building damage can range from minor cracking of plaster to total collapse. Disruption of infrastructure facilities could include damage to utilities, pipelines, roads, and bridges, etc.

Secondary effects can include the occurrence of ground and slope failure and possible sympathetic movement along other faults. Major costs may be incurred in the repair or replacement of damaged structures and facilities.

Local Conditions

Santa Barbara could be affected by ground shaking occurring from fault movement from a local fault or a more major, distant fault. Table 1 shows the estimated maximum credible and design earthquake magnitudes occurring in Santa Barbara due to movement along significant faults within the region.

It has been estimated that a 0.25 g bedrock acceleration could be considered as a constant throughout the entire City. This motion could be generated from several sources including the Mission Ridge, More Ranch, or an offshore fault (Hoover, 1978).

Variation of ground shaking intensity in the City will be brought about by variations in local, onsite soil and geologic conditions. The effects of site conditions have been studied by Seed, et al. (1975), Trifunac and Brody (1975), and Mohiaz (1976). Based on these studies, the City of Santa Barbara has been divided into four site conditions: Bedrock, Stiff Soil, Thicker Alluvium, and Filled Estero. These site conditions include the following surface geologic criteria:

1. Bedrock - all Tertiary rock exposures except the Rincon Formation.

2. Stiff Soils -

    a. Fanglomerate.
    b. Santa Barbara Formation.
    c. Turace Deposits.
    d. Alluvium less than 30 feet thick.
    e. Rincon Formation.

3. Thicker Alluvium - greater than 30 feet thick. This includes recent and older alluvium.

4. Filled Estero - This artificially filled "semi-swamp" is characterized by unconsolidated sandy soils, a high groundwater level, and may be subject to liquefaction during strong earthquakes.

Another zone is that immediately adjacent to a rupturing fault. Certain shock waves generated by a ground-displacing fault may transmit extremely high ground motions (Hoover, 1978).

Estimates of the potential seismic hazard that the different soil conditions within the City could have on different types of structures are depicted in Table 2. The Geologic Map illustrates the location of the different soil types throughout the City of Santa Barbara. It should be noted that the figures shown generally apply to earthquakes generated by local sources. Distant events, such as those on the San Andreas fault usually have lower shock wave frequencies. In the cases of the "Larger" and "Older Larger" categories, this lower frequency would make bedrock behave much in the same manner as the stiffer soil class (Hoover, 1978).

ESTIMATED MAGNITUDE OF FUTURE EARTHQUAKES OCCURRING ON SIGNIFICANT FAULTS

TABLE 1

Fault Name	Length * (miles)	Distance from * S.B. area (miles)	Magnitude of Maximum Credible Event (50% rupture)	Magnitude of Design Earthquake (25% rupture)
Big Pine	53+	15	7½**	6.5
Lavigia	9.5	0	5.9	5.4
Mesa/Rincon Creek	14.5	0	6.2	5.7
Mission Ridge Arroyo Parida	21+	0	6.5+	5.8+
More Ranch	30	0-8	6.8	6.0
Pitas Point	8+	25-	5.8+	5.2+
Red Mountain	40+	6+	7.0	6.3
Santa Ynez	80+	8	7½**	6.6+
San Andreas	620	40	8¼**	n/a

* Lengths of faults assumes that new fault begins at major juncture. Imprecise location of offshore faults precludes exact determination of distance to the City of Santa Barbara.

** Greensfelder, 1973.

Note: This method of analysis assumes that the fault in question be considered active. As discussed in the text, this has not been substantiated for all faults listed. Since all faults are at least potentially active, however, seismic analysis is made for each.

SEISMIC HAZARD LEVELS

TABLE 2

Design Earthquake

Bedrock Acceleration .25g Duration 20 sec.

	1-3 Stories	Larger*	Old Larger
Bedrock	Low	Low	Moderate
Stiffer Soil	Low	Low-Moderate	Moderate
Thicker Alluvium	Low	Moderate	Moderate-High
Filled Estero**	Low-Moderate	Moderate	Moderate-High

Maximum Credible Earthquake

Bedrock Acceleration .5g Duration 40-60 sec.

	1-3 Stories	Larger*	Old Larger
Bedrock	Moderate	Moderate	Moderate-High
Stiffer Soil	Moderate	Moderate	High
Thicker Alluvium	Moderate	Moderate-High	High
Filled Estero**	Moderate-High	High	Very High

* Normal Design - Specially designed buildings such as newer hospitals would have lower hazard.

** Hazards in Filled Estero primarily reflect dynamics in subsurface soils rather than simple transmission of seismic waves.

Hazard Reduction

Hazard reduction of the potential impacts of ground shaking can be classified into two types of action. The first would be actions related to structural protection, i.e., actions taken to ensure that the design and construction of structures are adequate to withstand future probable or maximum ground shaking intensities and remain in a safe and operable condition. A detailed discussion of possible actions of this type is included under "Structural Hazards."

The second type of action would be that associated with land use planning decisions, which also is discussed in more detailed terms in a later section. The recommendations below describe actions generally related to both structural and land use decisions on a general basis. More specific recommendations are discussed in the other referenced sections.

Recommendations

1. Given that the possibility for greater ground shaking potential exists in some areas (i.e., filled estero lands) for larger structures, these areas should be given special consideration. Santa Barbara should encourage the performance of regional and local studies by qualified federal and state agencies such as the U.S. Geological Survey and the California Division of Mines and Geology, private research firms, and universities to more accurately determine the potential for increased ground shaking.

2. Specific seismic investigations shall be conducted by appropriate consultants (engineering geologist, geophysicist, structural engineer, etc.) for all public buildings, disaster response facilities, schools, etc., and any structure over three stories located in the filled estero or thicker alluvium areas as shown on the Seismic Hazards Map.

3. Investigate possibilities of obtaining comprehensive earthquake insurance for public and private residential, commercial, and industrial facilities.

4. Require the design and construction of utility systems and other facilities which need to remain operable after an earthquake to be able to resist strong ground shaking forces.

5. Design and install auxiliary equipment, facilities, and machinery which must remain operable after an earthquake to resist strong ground shaking forces.

6. Lateral bracing requirements for mobile homes should be improved to prevent the trailers from falling off their foundations.

Structural Hazards

General Description

Any type of structure, if inadequately designed or constructed to withstand the expected intensities of earthquake-generated ground shaking, may experience severe damage or complete collapse during a strong earthquake. It is currently economically infeasible, using state-of-the-art construction techniques, to build a totally earthquake-proof structure. This creates a certain level of risk. It is possible, however, to reduce this level of risk to an acceptable or tolerated level by using the appropriate building techniques. How well a structure performs in a strong earthquake is closely related to the structure's construction characteristics. Different construction materials have varying strength values;

consequently, they react to the earthquake forces differently. The shape of a building and the geometry of the earthquake-resisting frames can also have a considerable influence on the amount of damage suffered by a building during an earthquake. These and other characteristics will combine to determine the fundamental period of the structure, which is a main factor in determining the oscillation level or degree and type of shaking the structure is subject to.

1. Wood frame buildings - Small one and two story wood frame structures traditionally survive the effects of ground shaking quite well. This is due mainly to their flexibility and light weight; such buildings are practically uncollapsible. Large wood frame buildings of two or more stories may be badly damaged during an earthquake, but usually they do not totally collapse. However, wood frame buildings are fire prone. In past big earthquakes, most wood frame buildings have survived the earthquake, but have been destroyed by post-earthquake fires.

2. Steel frame - These buildings are also very flexible structures and will usually survive ground shaking quite well. During an earthquake they may be damaged, but unless ground rupture occurs beneath them, they do not totally collapse. Braced structural steel buildings are less flexible, and if they lose the bracings, they may collapse.

3. Reinforced masonry buildings - When properly designed and constructed, reinforced masonry structures can survive design earthquakes. However, they are brittle and in strong quakes they crack or collapse. Improperly poured or poor quality concrete will increase the possibility of building failure considerably.

4. Unreinforced masonry - This includes such building materials as unreinforced concrete and brick, hollow concrete block and clay tile, and adobe. Buildings constructed from these materials have little earthquake resistance. They are heavy, brittle buildings; in small earthquakes they crack, and in stronger quakes they have a tendency to collapse.

Nonstructural items and building components can also influence amounts of damage suffered during an earthquake. Unreinforced parapets and chimneys, facades, signs and building appendages can all be shaken loose during an earthquake, creating a serious risk to life and limb.

A landmark in earthquake safety engineering legislation was passed by California after the 1933 Long Beach earthquake, when the State adopted the Field and Riley Acts, and established the State Office of Architecture and Construction. The Field Act placed the design of schools under the supervision of the newly created Office of Architecture and Construction. The Riley Act placed design requirements on other buildings used for human occupancy, other than dwellings designed for two families or less. As a general rule, buildings constructed after 1933 have performed better and are generally considered safer than most buildings constructed before 1933.

Since 1933, building codes have been continuously improved as after each earthquake, new lessons are learned on the adequacy of the old codes. In 1961, several major building code amendments were enacted to strengthen buildings and improve their resistance to earthquakes. It is generally held that buildings constructed to meet the post-1961 seismic safety code requirements will fare better in earthquakes than buildings before 1933 or between 1933 and 1961.

Critical Facilities

In the hours immediately following the 1971 San Fernando earthquake in southern California, emergency services were impaired by damage to police and fire stations, communication networks and utility lines. A number of major hospitals in the area were seriously damaged and were unable to continue functioning at the time they were needed most. These and other facilities are vital to the community's ability to respond to a major disaster and to minimize the loss of life and property. The experience in San Fernando emphasized the need to provide these "most critical" and "critical facilities" with a higher level of protection from earthquakes than noncritical structures. As a minimum, all structures which could have an effect on the loss of life should be designed to remain standing in the event of a major earthquake even if rendered useless. "Most critical" facilities, on the other hand, should not only remain standing, but should be able to operate at peak efficiency in the event of a disaster. Designing a building to this higher level of seismic safety entails not only a stronger structure, but also greater attention to nonstructural items such as elevators, lighting, and storage facilities.

Deciding which types of facilities are to be considered critical and non-critical is part of the public decision on acceptable risk. The following table presents a recommended categorization of buildings and design earthquakes for those categories.

TABLE 3

Category	Facilities
Most Critical	Hospitals, Civil Defense Communications, Water Supply Facilities, Fire and Police Facilities, Telephone Communication Facilities, Electrical Substations
Critical	Schools, Theaters, Auditoriums, Clinics, Utility Systems, Bridges, Pipelines, Major Public Areas including Shopping Centers, Parks, Convention and Conference Facilities, Rest Homes
Non-critical	Low-density Residential, Commercial, Industrial, Office, and Similar Uses

Effects of the Hazard

The primary effect of hazardous structures in the community is the potential for the loss of life and property. During an earthquake, damage to a structure can range from superficial damage to complete and total collapse.

Structural failure can also lead to the disruption of transportation, communication and power systems, all vital to emergency response. The loss of structures which house vital or critical facilities after a major disaster will seriously hamper emergency rescue operations.

Local Conditions

The most serious risk from possible structural failure during a major earthquake exists in the Downtown and Lower State Street areas of the City. These areas contain the greatest concentration of unreinforced masonry buildings in the City, and historically the major losses incurred during earthquakes have occurred in these areas. Preliminary surveys show that approximately 70-80 percent of the existing structures in these areas were built before 1933. Among these structures are included numerous commercial and retail shops, theaters, and hotels.

It would be inappropriate, however, to categorically state that all pre-1933 structures in Santa Barbara represent a serious collapse hazard in strong earthquakes. Many of the buildings that survived the 1925 earthquake, or were reconstructed afterwards, such as City Hall, Granada Building, Post Office, and County Courthouse, have withstood several earthquakes without experiencing major damage. The adequacy of earthquake protection each building provides must be assessed on an individual basis.

Outside of the Downtown, Lower State Street area, most of the construction consists of small, wooden frame residences or newer construction. The risk of building failure, therefore, is not considered to be as significant.

Hazard Reduction

1. To reduce the risk associated with the use of existing older structures that do not conform to present day earthquake safety standards, a survey of high-density residential, commercial, and industrial structures should be conducted throughout the city. The survey should concentrate on the Downtown and Lower State Street areas as most of the hazardous buildings are likely to be located there (Mendes, 1979). The objective of this survey should be to identify buildings constructed during the following time frames:

    a. Pre-1925 - Very poor to fair performance during earthquakes due to inadequate knowledge about earthquake-resistive design and construction. Additionally, before this time no Building Department existed in Santa Barbara.

    b. 1925-1926 - This era in Santa Barbara history constitutes the reconstruction period after its most destructive earthquake (see Seismic History, page 24). During a severe earthquake, performance of buildings constructed during this time would be poor to fair. This is due to the fact that few buildings were materially improved and were only repaired.

    c. 1926-1950 - Buildings constructed during this period would be expected to exhibit fair to good earthquake characteristics due to better design and attention to tying all parts of the building together.

    d. 1950-1973 - Due to variable performance of design professionals, adequacy of available knowledge, and use of "too little judgment," building performance during a severe earthquake could range from poor to excellent.

e. 1973-Present - After the lessons learned about earthquake- resistive design in the 1971 San Fernando earthquake, buildings constructed since 1973 should perform excellently in a severe earthquake.

In addition, buildings that are constructed from materials that do not usually perform well in earthquakes (i.e., unreinforced masonry, clay tile, and adobe) should be given special consideration, regardless of their date of construction.

From this survey, a list of priorities, or buildings that represent the largest degree of risk, should be developed. Consideration for the rehabilitation of structures should proceed in a manner shown below in Table 4.

TABLE 4
STRUCTURAL HAZARDS PRIORITY MATRIX

	CRITICAL	MOST CRITICAL	NON-CRITICAL
←1925	1	2	7
1925-26	3	4	8
1926-50	5	6	9
1950-73	10	11	12
1973→	13	14	15

The criteria used in establishing the level of risk involved with the use of each structure should consider the potential for:

a. Significant threats to human life.
b. Unacceptable levels of potential economic loss.
c. Widespread social disruption.

The goal of structure upgrading should be to provide an acceptable level of risk to the occupants of the building and to the community at large. To do this, after building upgrading has taken place, the structure should be required to be able to:

a. Resist minor earthquakes without damage.
b. Resist moderate earthquakes without structural damage, but with some non-structural damage.
c. Resist the design earthquake without collapse, but with some structural as well as non-structural damage.

After a list of priorities for building rehabilitation has been established, the City should investigate and adopt an action plan to carry out the abatement of structural hazards. This action plan should include measures that would consider the following:

a. Relocation of persons displaced from hazardous structures.
b. Tax incentives for the owners of hazardous structures for rehabilitation.
c. Investigation of the use of state and federal grants and loans to conduct hazardous building abatement program.

2. The City Building Official should review the Uniform Building Code and make recommendations on seismic engineering requirements for new buildings and the modifications of existing structures. If found to be inadequate, the development of new code requirements should be considered.

3. The City's Land Use Element, Zoning Ordinance, Subdivision requirements, and Grading Ordinance should be reviewed and amended, where necessary, to incorporate seismic safety considerations. Procedures should be established for requiring geologic site investigations in areas of high hazard, particularly when critical facilities are involved.

Liquefaction

General Description

Liquefaction is a temporary, but substantial, loss of shear strength in granular soils, such as sand, silt, and gravel, usually occurring during or after a major earthquake. This occurs when the shock waves from an earthquake of sufficient magnitude and duration compact and decrease the volume of soil; if drainage cannot occur, this reduction in soil volume will increase the pressure exerted on the water contained in the soil, forcing it upward to the ground surface. This process can transform stable granular material into a fluid-like state similar to quicksand.

The potential for liquefaction to occur is greatest in areas with loose, granular, low-density soils, where the water table is within 55 feet of the ground surface (Hoover, 1978).

Effects of the Hazard

Liquefaction may manifest itself by the development of cracks in the ground surface, followed by the emergence of water from the ground. Considerable depths of water may accumulate on the ground surface, and characteristic sand boils, sand volcanoes, and sand ridges, all created by the emergence of the water may form. When quicksand conditions develop, buildings and other objects on the ground surface may tilt or sink, and lightweight buried structures may float to the surface.

Extreme settlement of the ground may result from liquefaction. In areas underlain by thick deposits of sediment, subsidence of as much as several feet may occur, creating new shorelines in areas near bodies of water. Ground settlement often occurs differentially as the sand and water are seldom removed evenly over broad areas. Liquefaction may also lead to the lateral spreading of soft saturated soils. This can result in the rapid or gradual loss of strength in the foundation materials so that structures built upon them gradually settle or break up as the foundation soils flow out from beneath them.

If liquefaction occurs in a layer of soil below the ground surface, the liquefied layer can act as a slip-plane or similar to ball bearings and cause large, destructive landslides. This can occur on slopes as gentle as 2.5 percent (United States Geological Survey, 1974).

Local Conditions

Areas in Santa Barbara that generally have high groundwater levels and poorly consolidated sandy soils have been delineated as having a high liquefaction potential during a major earthquake. These areas generally coincide with the land that is filled estero.

This area includes the waterfront from the base of the "Mesa" eastward to the Andree Clark Bird Refuge, and then extends inland to cover most of the West Beach, East Beach, Lower East and Laguna neighborhoods. The Municipal Airport, located in the Goleta Slough, also has a high liquefaction potential.

Areas in the City that have soils of mixed sand and clay, with historic high groundwater levels have been outlined as having a conditional liquefaction potential. Liquefaction could occur in these areas if groundwater levels were to return to their historic high levels. This area includes most of the Lower State, West Downtown, and Hidden Valley neighborhoods, and the area surrounding Mission Creek where it runs parallel to U.S. 101.

A minimal liquefaction potential has been assigned to areas with groundwater levels historically below 40 feet and having high soil densities. The Liquefaction Hazard Map depicts the areas where these different liquefaction potentials exist.

Hazard Reduction

The potential for liquefaction to occur during a major earthquake can be determined by conducting site-specific soils investigations. From these soil surveys several methods of mitigating the hazard are possible:

1. Future development should consider incorporating the "vibro'replacement" technique of construction utilized in the expansion of the City's sewage treatment facility. This process will create many small vertical drains in the soil, thus decreasing the pressure exerted on the water contained in the soil during an earthquake.

2. Removing the objectionable soil material and replacing it with well-compacted artificial fill under the supervision of a qualified soils engineer. An extensive dewatering or drainage system would have to be used in conjunction with the new fill material if the water table is near the ground surface.

Recommendations

1. Liquefaction evaluations and recommendations should be made by a qualified soils engineer for all new major or public structures located in high or conditional liquefaction potential areas (shown on the Liquefaction Hazard Map) whose failure could result in loss of life or high monetary loss.

2. A committee of independent registered engineering geologists should be formed to develop a framework and format for geologic reports which are prepared for areas of potential liquefaction.

3. Geologic reports which are prepared for areas of potential liquefaction and submitted for City review shall be sent for review by an independent registered engineering geologist to determine their adequacy and completeness.

Tsunamis

General Description

Tsunamis or seismic sea waves are large ocean waves generated by a vertical displacement of the ocean floor, usually by a large earthquake. These waves may travel hundreds or even thousands of miles in the open ocean and still maintain enough energy to be destructive when they reach shore. The general public has long referred to these waves as "tidal waves" but this is a misnomer, as there is no connection between a tsunami wave and the tides.

In the deep ocean, tsunami waves may be only a few feet in height and cannot be felt aboard ships, and normally cannot be seen from the air; wave energies are nonetheless impressive. As a tsunami enters the shallow water along the coast, its velocity can diminish from over 600 miles per hour to less than 40 miles per hour. This change in velocity transfers the wave's energy from one of wave speed to one of wave height. The eventual size of the tsunami wave when it reaches shore is directly related to the magnitude of the ground-displacing event and any amplifying effects the local coastline configuration may have. Tsunamis have been known to attain heights of 50 to 100 feet.

Tsunamis are a unique hazard in that the arrival time of a wave generated far out at sea can be predicted quite accurately, to within a minute and a half per elapsed hour. Unfortunately, the intensity of the wave when it reaches shore cannot be predicted. The threat of the tsunami hazard is compounded by the fact that the waves can come in succession over a period of ten to twelve hours, making the duration of the threat quite long.

Effects of the Hazard

The primary cause of loss of life and injury from a tsunami results from the lack of a well-organized warning and evacuation plan, and the failure of persons located in danger areas to heed warnings or evacuation directives. Other injuries and fatalities result from the failure to keep people out of the danger area for the duration of the threat.

Damage caused by tsunamis is most severe at the water's edge, where boats, harbor, buildings, transportation systems, and utilities may be damaged or destroyed. In addition, the waves may be disastrous to aquatic life, including fish, mollusks (clams, etc.) and plants.

History of the Hazard

Within the past 100 years, several tsunamis have been generated in the Pacific Ocean causing severe damage in Alaska, Japan, Indonesia, and Chile. None of these events had any appreciable effect on the southern Santa Barbara County coastline. There are, however, historical records of tsunamis being generated within the Santa Barbara Channel and hitting the Santa Barbara coast in 1812 and 1927. Details on the 1812 tsunami are conflicting and not well documented. Stories of a 50-foot wave striking Gaviota and a 30 to 35-foot wave with a run-up of half a mile inland at Santa Barbara are recorded by only two accounts. One would expect that if an event of such a magnitude had actually occurred, it would have been more extensively documented in historic accounts.

There is no doubt, however, about the magnitude of the 1927 tsunami generated off Point Arguello, California. The largest waves generated by this 7.5 magnitude earthquake were less than six feet in Santa Barbara, and damage was minor (Santa Barbara County Seismic Safety Element, 1970).

Local Conditions

An earthquake originating in the Santa Barbara Channel could produce a wave height just as large as a major distant earthquake, and would not be likely to provide adequate warning for evacuation procedures to be implemented (Santa Barbara County Seismic Safety Element, 1978).

The 1925 earthquake, which had a 6.3 magnitude and was probably epicentered offshore, did not create a tsunami. It appears that the magnitude of an earthquake necessary to generate a tsunami within the Santa Barbara Channel must exceed 6.5, and the potential for a severe tsunami would begin when the magnitude is greater than 7.5 (Dames and Moore, 1973).

In planning for future tsunami waves that could affect the Santa Barbara coast, a ten-foot-high wave and a wave run-up to the 40-foot elevation contours should be considered maximum. This elevation is somewhat arbitrary and considers the possible limits of run-up in lowland-gentle sloping areas. It does not mean that a high level of destruction would necessarily result at that elevation. Areas lying below the 10-foot elevation contour would be most susceptible to inundation and damage (Santa Barbara County Seismic Safety Element, 1978).

In the areas where steep bluffs 15 feet or more in height are exposed to the ocean along the coast, the tsunami threat is not considered serious. These bluffs would act similarly to sea walls and reflect the anticipated maximum 10-foot-high sea waves. However, because of the channeling effect created at some areas where high promontories are present and narrow, constricted entry channels are formed, inundation due to run-up could be substantial (Santa Barbara County Seismic Safety Element, 1978).

Damage from a large tsunami wave and the resulting wave run-up would be most severe in the West Beach, Lower State, and East Beach neighborhoods. Damage could also be heavy in the area near Arroyo Burro Beach and at the Municipal Airport. Also located below the 40-foot elevation contour and subject to tsunami wave run-up are the lower portions of the West Downtown, Milpas, and Eastside neighborhoods.

Hazard Reduction

Deciding what precautions should be taken when planning for the tsunami hazard is difficult, not only because the severity of the hazard is hard to ascertain, but because of the very low, unknown frequency of occurrence. Considering the value of coastline property, the prohibition of building does not seem to be justified. The loss of life due to a tsunami should be of more concern.

Recommendations

1. Tsunami warning and evacuation procedures as outlined in the City of Santa Barbara Natural Disaster Plan will be periodically reviewed and amended to insure that it will facilitate the rapid and orderly evacuation of the hazard area in the case of an imminent tsunami.

2. Conduct simulated tsunami warning operations involving Police, Fire, Public Works, Harbormaster, Airport, and any other agency concerned

with tsunami warning and evacuation. This will serve to effectively familiarize each agency with their specific duties and responsibilities, and to pinpoint inadequacies in the evacuation and warning procedures.

3. Amend and update as necessary the Disaster Contingency Plan for tsunamis to reflect any changes in warning and evacuation procedures that are found to be needed after conducting the simulations. Concerned agencies will then be made aware of any changes in their duties and responsibilities.

4. Familiarize the general public located in tsunami hazard areas with the nature and extent of the tsunami hazard and with warning and evacuation procedures. This may be done through mailings, news media, public service announcements, and adult education.

5. Develop a warning system to alert boat owners with boats in the harbor of an imminent tsunami so as to allow them to move their boats to open water.

Seiche

General Description

A seiche (pronounced sāsh) is a wave or series of waves set up in an enclosed body of water by wind, earthquake, or landslide. They can be likened to the oscillations produced by the sloshing of water in a bowl when it is shaken or jarred. Seiche most commonly occurs in lakes, bays, and harbors.

Ground shaking or ground displacement due to faulting may set up a seiche wave by creating dangerous wave forming oscillations in the water, or by causing rapid water displacement respectively. Landslides, either triggered seismically or in some other manner, may fall into an enclosed body of water, displacing a large amount of water and create a destructive wave. Tsunamis, by causing rapid changes in sea level, or more commonly, by the wave itself, may also cause seiche to form in harbors and bays.

Effects of the Hazard

The primary effect of a large seiche is the inundation and possible damage or destruction of structures and facilities in or very near a lake, bay, or harbor. Large seiche can overtop dams in manmade lakes and reservoirs, causing flooding to occur downstream.

Local Conditions

A seiche hazard is present in all lakes and uncovered reservoirs located in the City. Due to the relatively small size of the Andree Clark Bird Refuge and Laguna Blanca Lake, and the limited amount of development surrounding them, they do not present a serious seiche risk (Coudray, 1970). Escondido and Vic Trace reservoirs located on the Mesa are covered reservoirs and do not present a seiche risk.

A more serious seiche risk exists from the Lauro Canyon and Sheffield reservoirs. The Lauro Canyon Reservoir is located just outside the City limits, but a wave overtopping the dam would inundate areas in the City along San Roque Road below the dam. A wave overtopping Sheffield Reservoir would empty into Sycamore Creek and inundate Sycamore Canyon. The level of risk from these reservoirs has been reduced by water levels being kept quite low. If water levels were to be raised, the potential risk from a seiche would be increased.

The Santa Barbara City Harbor is also susceptible to the damaging effects of seiche. Boats, wharfs, and structures near the harbor could all be affected. Open bodies of water that could produce a seiche wave are shown on Figure 3.

Recommendation

1. To reduce the potential impact of seismically induced seiches, the seiche hazard should be considered in all development within areas near open bodies of water and the harbor.

2. Investigate and take appropriate action to mitigate any potential seiche hazard related to the Lauro Canyon Reservoir.

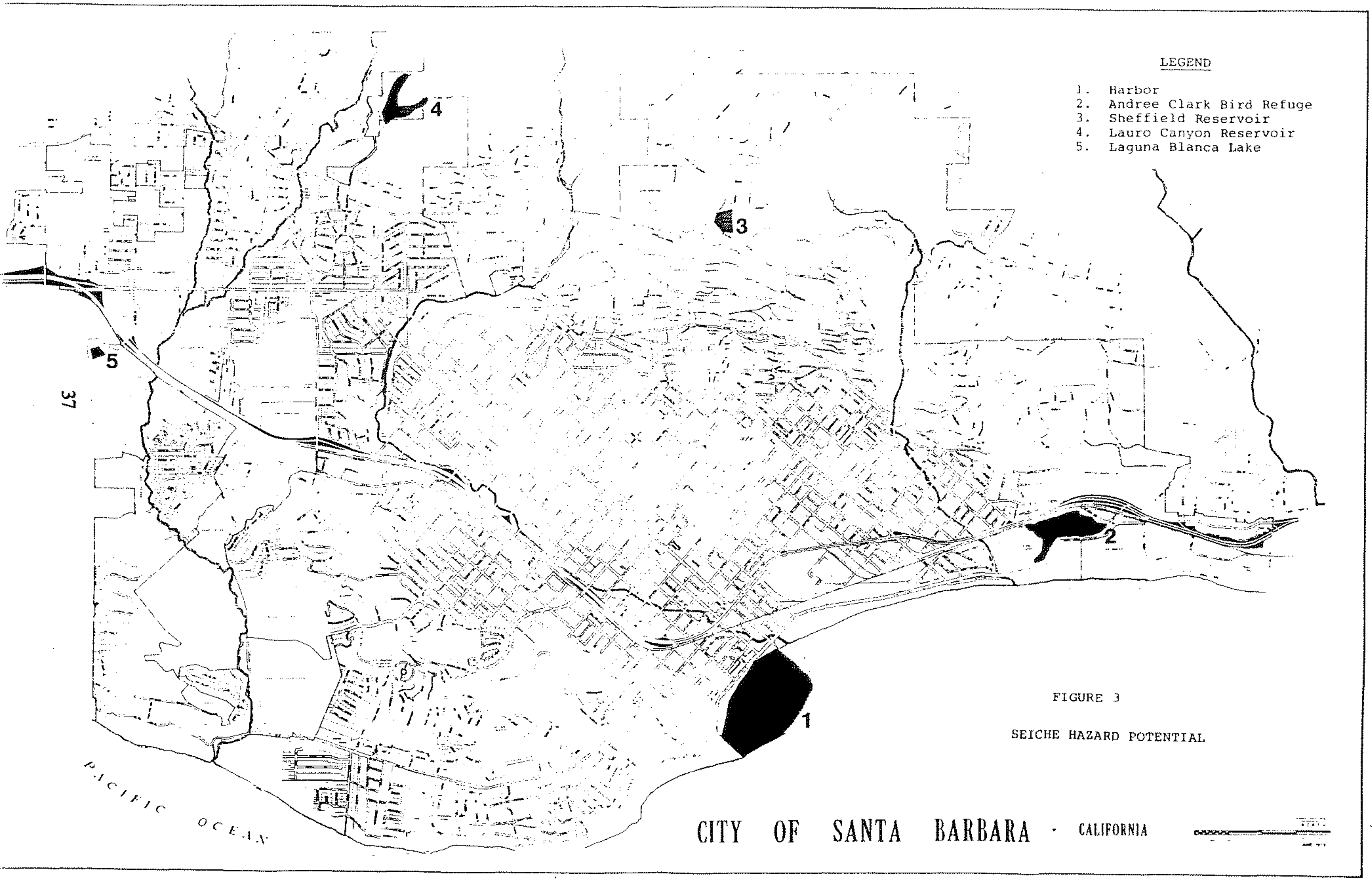


FIGURE 3

SEICHE HAZARD POTENTIAL

Landslides

General Description

The occurrence of landslides is a part of the continuous, natural process of the downhill movement of soil, rock, and rock debris. The speed at which this earth material moves downslope can range from the almost imperceptible creep of soil and rock material to sudden mass movements of an entire hillside. It should be stressed that these events are natural occurrences and would occur with or without human activity. Human interference, however, can often increase the frequency and extent of landslides.

The causes of landslides can be examined by studying relations between forces which tend to make earth material slide (driving forces) and forces which tend to oppose such movement (resisting forces)(Keller, 1976). Driving forces acting on a slope are the weight of the slope material, and the weight of objects placed on the slope, such as snow, water, buildings, artificial fill, swimming pools, etc. Resisting forces are supplied mainly by the shear strength of the slope material, or the ability of the slope to support its own weight and resist the forces of gravity that try to pull it downhill. Resisting forces can be lowered most readily by the addition of water to the slope, as water will add excess weight to the slope material and act as a lubricant to facilitate movement. Landslides commonly occur during and after earthquakes as shocks and ground vibrations can act as the immediate cause, or a triggering device, setting ground or debris material that was in an unstable condition into motion. Hillside development can also act to turn a stable slope into an unstable slope by steepening the slope angle, increasing the height of the slope, and placing extra weight loads on the slope.

Effects of the Hazard

Slope instability that results in landslides can cause substantial damage and disruption to the works of man. Some of these losses can include possible loss of life; displacement and destruction of buildings, roadways, and other improvements; blockage of drainage channels; disruption of transportation and communication systems; and the loss and disruption of utility and pipelines.

A secondary effect of the landslide hazard that could have significant impacts in the future are lawsuits initiated against the developer of the property affected by the landslide, as well as the present owners and the governmental agencies which may have reviewed the development, approved the plans and issued the grading and/or building permits.

Local Conditions

Because of variations in the inherent stability of different geological formations, some are much more prone to landsliding than others. In Santa Barbara, one of the more troublesome geologic units is the Rincon Formation. Commonly found in the foothills of the eastern halves of the Riviera and Cielito neighborhoods, the Rincon Formation forms grass-covered hills whose smooth, rounded slopes encourage development. Unfortunately however, this formation weathers to form unstable, heavy, expansive clay soil that slumps naturally and frequently.

Another formation found in Santa Barbara that is susceptible to landslides is the Monterey Formation. This formation often contains beds of highly expansive Bentonite clay that may act as a slip plane and cause the slope material deposited over it to slide downhill. The Monterey Formation comprises most of the sea cliff in Santa Barbara, and is also found to outcrop in the Riviera and Eucalyptus Hill areas.

Landslides mapped in Santa Barbara have been divided into two separate categories:

1. Active - Slides that have apparently moved during historic times (past 100 years). Movement is evaluated by the existence (or lack) of vegetation and fresh scarps, plus historic observations.

2. Inactive - Slides that are discernible from morphology, apparently have not been active during the past 100 years.

Most active and inactive landslides mapped by Hoover (1978) are located in the eastern Riviera and Cielito areas where outcrops of Rincon Formation are found, and along the shoreline where the sea cliffs are being eroded. Both active and inactive landslides located in Santa Barbara are shown on the map titled, "Soil Creep and Expansive Soil."

Hazard Reduction

The first and most critical step in preventing losses due to slope instability is to locate potential areas of landslide activity. These areas are usually delineated by mapping the presence of old landslides. This is accomplished by conducting detailed geologic mapping, trenching, drilling, and photo interpretation of surface geologic conditions. Old landslides can often be recognized by their lobe-like shapes, hummocky surface, scarps, and characteristic pressure ridges that form where the earth material stops moving.

Once an area is recognized as potentially hazardous landslide area, future development can be designed to take this hazard under careful consideration. Several methods of minimizing landslide risks include:

1. Leaving hazardous areas undeveloped.

2. Removal of unstable slope material.

3. Well engineered grading prior to construction.

4. Provisions for surface and subsurface drainage.

5. Construction of retaining walls or other barriers to buttress old slides.

6. Reduce the driving forces acting on the slope by reducing the slope angle or the weight of objects placed on the slope.

7. Planting drought resistant vegetation with deep, strong root systems.

Once movement of slope material has started, the best way to stop it is to deal with the factor that initiated the slide. This will usually require the removal of water from the unstable layers of the slope by increasing drainage with trenches, drill holes, or other dewatering mechanisms.

Recommendations

1. Any proposed development within areas of active and inactive landslides as shown on the Soil Creep and Expansive Soil Map shall be evaluated by a qualified soils engineer to determine the feasibility of safe development occurring without the risk of renewed movement. The soils report shall include recommendations for slope stability measures to be taken, if needed, for safe development to occur. This report will be subject to the approval of the Building Official.

2. Major grading operations undertaken in areas of active and inactive landslides shall be designed and supervised by a qualified soils engineer.

3. The Building Official should establish procedures whereby expert consultants shall make independent reviews of geologic reports in hazardous areas to assist him in determining adequacy of analysis and problem solutions.

High Groundwater

General Description

Near-surface groundwater can present itself either as an aquifer or in a perched condition. An aquifer is a layer or body of porous earth material containing sufficient water that it can be pumped out. Highly fractured rocks and unconsolidated sands and gravels make good aquifers. Perched groundwater results from water percolating downward and collecting above a lens of impermeable material. Perched groundwater is isolated from the underlying main groundwater body. This zone is not a reliable source of groundwater because the total water available for extraction is often limited.

Effects of the Hazard

The presence of a high groundwater level by itself does not always present a major hazard to new development as engineering practices can often mitigate any potential problems. High groundwater, however, can present a hazard from the aspect of increasing the potential severity of liquefaction, settlement, and slope stability hazards as well as presenting construction difficulties and a general nuisance.

The potential severity of a high groundwater hazard is dependent on groundwater levels with respect to the ground surface. Water in the upper eight feet might impose a problem to the construction of foundations, basements, utilities, roads, septic tanks, etc. It would affect the load capacity of the soil for major structures. Generally, water between 8 and 15 feet could pose a problem for larger structures and deeper excavations. Water below 15 feet would not constitute any significant problem except for the largest structures or those requiring deep excavations such as major storm drain or sewer projects (Santa Barbara County Seismic Safety Element, 1978).

Local Conditions

Estimated groundwater levels as of August 1977 for the parts of Santa Barbara that lie within the Santa Barbara Groundwater Basin are shown on Figure 4. Areas of the City outside the Groundwater Basin overlie bedrock formations that are generally not water-bearing. Groundwater levels vary widely throughout the City, ranging from sea level along the coast to 400 feet below mean sea level (MSL) in the northern foothill sections of the City.

Due to the high number of active wells pumping groundwater in the Downtown area, groundwater levels in the area roughly between State and Salinas Streets and U.S. 101 and Canon Perdido have been lowered approximately 20 feet below the recorded levels of the immediately surrounding vicinity (Todd, 1978).

Water levels shown on Figure 4 are not static or permanent levels over time. Groundwater levels may fluctuate due to changes in seasonal and short-term climatic conditions, and pumping rates. Groundwater levels for this report were estimated after several dry years and could be slightly lower than estimates taken after several wet years.

Recommendations

1. In areas where near surface groundwater is present or where historic high groundwater levels could return to their previous high levels, soils engineering and foundation studies shall be conducted to determine what engineering measures would best mitigate any potentially adverse impacts.

Expansive Soils/Soil Creep

General Description

Expansive soils are clay-rich soils that will experience changes in volume in direct response to water content. These soils will swell in volume when water is added to them, and shrink when they become desiccated. The water may be derived from moisture in the air or groundwater beneath the foundations of buildings. Once an expansive soils problem has been recognized by soils testing, corrective measures can be designed into the foundation of structures with little additional cost. Corrective measure costs after construction, however, can be quite high.

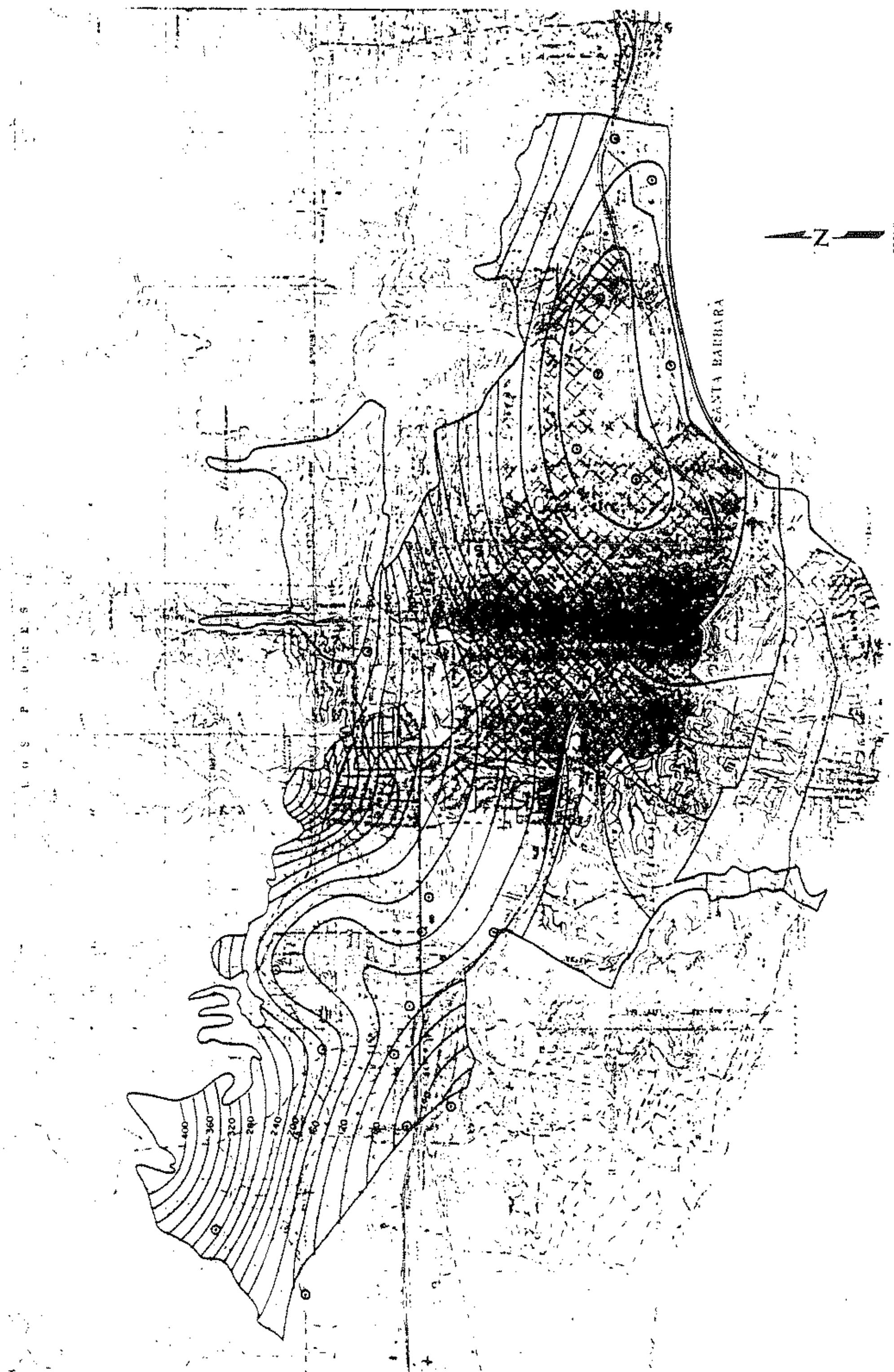
Soil creep is the slow downslope movement of surface soils. It usually involves clay-rich soils and is due, at least in large part, to wetting and drying (swelling and contracting). Vegetation root growth can also facilitate the downslope movement by wedging soil particles loose. Rates of soil creep can be directly related to the steepness of the slope and the expansiveness of the soil. Soil creep, like expansive soils, can be detected in advance by conducting thorough soils surveys, thus effectively mitigating potential impacts of the hazard.

Effects of the Hazard

When structures are placed on expansive soils, foundations may rise each wet season and fall with the succeeding dry season. Movements may vary under different parts of a structure with the result that foundations, walls, and ceilings crack, various structural portions of the building are distorted, and doors and windows are warped so they do not function properly.

Soil creep usually occurs near the tops of slopes, so adequate setbacks will protect most structures. During periods of prolonged rain, the soils may become saturated and slump (a small shallow form of landslide). Signs of soil creep can be seen in such features as curved trees, and tilted fence and telephone poles.

Figure 4 Santa Barbara Water Table contours



Estimated Water Table Contours in the Santa Barbara Groundwater Basin as of August 1977. Contour Values in Feet MSL.

Local Conditions

Areas in Santa Barbara that have expansive soil/soil creep problems are usually areas where outcrops of the Rincon and Monterey Formations are found. The Rincon Formation is considered to be one of the most expansive soils to be found in southern California. Areas underlain by the Sespe Formation have also been known to have expansive soils problems.

Areas in Santa Barbara subject to the effects of expansive soils are delineated on the <u>Soil Creep and Expansive Soils Map</u>. These areas have been divided into three separate categories:

1. Highly Expansive to Very Highly Expansive Clay Soil - These areas are usually related to the Rincon Formation and generally range in expansiveness from 12 percent to 45 percent (at 60 psf* surcharge). Such expansiveness can damage unreinforced concrete walls, patios, driveways, or foundations.

2. Moderately Highly Expansive Soil - These areas are generally related to the Monterey Formation. Expansiveness is usually 6 percent to 12 percent (at psf* surcharge). This level of expansiveness can damage unreinforced (or non-engineered) patios, driveways, and retaining walls.

3. Variable Soil Conditions - Soils in this area are quite diverse and usually contain interlayered sandstone and clay soils (Sespe Formation), or shale and clay soil (Monterey Formation).

Areas in Santa Barbara with a soil creep problem are also illustrated. Soil creep potential has been divided into three separate categories:

1. Active - Areas where downslope movement is reflected by topographic features (hummocky terrain), leaning trees, or structural damage.

2. High Potential - Probable creep, but not as noticeable as in active areas. Generally, soils are 5 to 25 feet thick, and highly expansive.

3. Low to Moderate - Areas with low probability of soil creep, except where soils are thick. Soils are generally 9 to 10 feet thick in these areas.

Hazard Reduction

As discussed earlier, comprehensive soil surveys conducted prior to construction can effectively mitigate possible soil problems caused by the presence of expansive soils or soil creep.

Some common methods of controlling the possible effects of expansive soils include:

1. Compaction and water content of the building site can be designed to allow some open spaces or voids. The voids will permit some expansion to take place within the soil mass and will prevent expansion of the entire graded section. Compaction to 85 percent of maximum optimum density with water contents several percent above optimum will commonly accomplish this.

2. The moisture content can be stabilized by soaking the building site and maintaining that water content during and after construction.

3. Concrete slab floors can be strengthened by increasing their thickness, and including reinforcing steel will allow the foundation to rise and fall as a unit.

4. Drains and water barriers can be installed around and under foundations to prevent water from entering the foundation area.

5. The building foundations can be extended downward by piers so that building structures rest on underlying nonexpansive materials. The piers can be tied together by grade beams that unite the foundation into a more rigid unit.

6. Gravel blankets have been used under concrete slabs.

Recommendations

1. Investigations by an engineering geologist and a soils engineer should be performed for all structures proposed in areas of active or high potential soil creep, as shown on the soil creep and expansive soil map.

2. A soils engineer should conduct investigations for all structures proposed in areas shown to have variable, moderate or highly expansive soils.

Erosion

General Description

Erosion (taken from the Latin word "erodere," to gnaw away), is the slow, natural process of the detachment and transportation of soil and rock particles of physical and chemical means. Rates of soil erosion are a function of many separate factors, including slope gradient, amount and rate of water flow, soil compaction, etc., all of which may vary considerably over a short distance. All soils are subject to some degree of erosion, but generally the soils most susceptible to erosion are loose, cohesionless soils of relatively small particle size. Soil erosion will result in the production of sediment, which is truly a resource out of place in that it depletes a land resource (soil) at its site of origin and reduces the quality of the water resource it enters. (Keller, 1976)

Normal rates of erosion can be drastically altered by human activities. By increasing the amount and velocity of overland water runoff and clearing away protective ground cover vegetation and root systems, severe erosion problems may be created. Erosion rates are often greatest in areas undergoing construction. Sediment yields from areas undergoing urban development can be as much as five to 500 times greater than in rural areas (Detwyler et al., 1972).

Effects of the Hazard

Uncontrolled erosion and sedimentation can have severe adverse physical, biological, aesthetic and economic impacts. It can result in reduced agricultural productivity, the loss of soil nutrients, the eutrophication of lakes and streams, reduction in reservoir capacity, a decrease in water quality, etc.

Local Conditions

The portions of the City subject to rapid erosion are generally areas with steep terrain and unconsolidated sandy soils. These areas are generally found along the sea cliffs, and along the topographically high Mesa, Riviera and Cielito areas. The Erosion Hazard Map (in the map packet) depicts four separate categories of erosion activity:

1. Active Erosion - Areas that undergo extensive active erosion during the winter and are characterized by active gullying and ongoing sedimentation. Actively eroding sea cliffs and landslides are included in this category, as well as stream channels.

2. High Erosion Potential - Steep areas, with slopes generally over 50 percent, that are likely to erode if vegetation is stripped and not replaced before rainy months. Generally included are soils forming over the unconsolidated sands of the Santa Barbara Formation, fanglomerate, recent alluvium, and steep slopes in the Sespe Formation.

3. Conditional Erosion Potential - Areas in which erosion may become more active if steep cut slopes are made. In general, only minor maintenance problems exist at the present. These areas are lithologically similar to category (2), but usually occur on flatter slopes.

4. Minimal Erosion Potential - Areas with insignificant rates of erosion.

Recommendations

1. Detailed grading plans with strict revegetation provisions shall be required for all sites of proposed structures in areas of active erosion or high erosion potential. If cuts greater than 4 feet in height are proposed, the grading plan should consider erosion control in areas with a conditional erosion potential.

2. Major construction projects in areas of active erosion or high erosion potential shall be required to implement erosion and sediment control procedures during the construction phase of the project.

RELATIONSHIP OF SEISMIC AND GEOLOGIC HAZARDS TO LAND USE PLANNING

Traditionally, economic considerations have been the major deciding factors in determining where particular land uses shall be permitted on City land, regardless of the presence of geologic hazards. This has often resulted in the creation of potentially hazardous land use practices that are not compatible with the existing geologic conditions. Over time, these incompatible land use patterns can become well established in the community, making any major alterations in these patterns complicated and expensive procedures. Other unsafe land use practices have been created as urban population numbers have continued to grow, and the amount of land suitable for development and relatively free of geologic hazards is becoming more scarce. This will apply pressure on local government to allow new development to expand into areas with significant geologic hazards that would potentially have adverse impacts on the future inhabitants of the area.

To encourage safe and consistent land use policy decision in the City of Santa Barbara, Table 4 illustrates specific land uses and activities, with their relationship to various seismic and geologic hazards which have been identified in this report. Since geologic hazards are found to exist with varying degrees of severity in even relatively small areas, the compatibility of each land use type has been divided into three separate categories: acceptable conditionally acceptable, and not acceptable. These classifications are based on the potential severity of each hazard and the ability of current state-of-the-art engineering technology to reduce the risk presented by the hazard to an acceptable level.

The most important factor illustrated in Table 4 is that those uses, activities and buildings which are essential to the continued functioning of the City in the aftermath of an earthquake should be located in only those zones of lowest hazard. Other activities whose characteristics of either occupancy or operation warrant special attention should be located only where design can assure that these will not collapse or suffer loss of function during a design earthquake. The chart, however, is not intended to provide a rigid definition of acceptable and unacceptable uses for each hazard zone. The suitability of a specific use for a location at a specific point should be evaluated in the light of soils and geological investigations. An area evaluated as generally unsuitable for a particular use does not necessarily preclude the use if no other suitable alternative site is available and provided that all potential hazards can be mitigated. However, if such hazards cannot be mitigated, prohibition of the use is the only alternative.

Although much of the land in Santa Barbara has already been developed, land use planning for new, as well as existing areas, should seriously consider the hazardous geologic processes discussed in this report. By utilizing prudent land use planning, the encroachment of incompatible land use into potentially hazardous areas can be avoided and the risk of loss of life, injury, economic loss and social disruption can be reduced.

TABLE 4, LAND USE ACCEPTABILITY

KEY

- ACCEPTABLE
- CONDITIONALLY ACCEPTABLE
- NOT ACCEPTABLE

	OPEN SPACE	LOW-MODERATE DENSITY RESIDENTIAL	OFFICE, MINOR COMMERCIAL	COMMERCIAL AND LIGHT MANUFACTURING	VISITOR SERVING	HIGH DENSITY RESIDENTIAL	CRITICAL FACILITIES	MOST CRITICAL FACILITIES
FAULT ZONE								
Active	Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
Potentially Active	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
Inactive	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable
GROUNDSHAKING								
Fault Zone	Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
Estero	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
Thick Alluvium	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable
Stiff Soils	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Bedrock	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
LANDSLIDES								
Active	Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
Inactive	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
LIQUEFACTION								
High Potential	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
Conditional Potential	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable
Minimal Potential	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
TSUNAMI								
Near Coastline, Below 10 Feet in Elevation	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
Near Coastline, Between 10-40 Feet in Elevation	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable
Near Coastline, Above 40 Feet in Elevation	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
SEICHE								
Potential Present	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Not Acceptable
Potential Not Present	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
HIGH GROUNDWATER								
0-8 Feet of Ground Surface	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Not Acceptable
8-15 Feet of Ground Surface	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable
15 Feet and Down	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
EXPANSIVE SOILS/SOIL CREEP								
Highly Expansive/Active Creep	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable
Moderately Expansive/High Creep Potential	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable
Variable Soil Conditions/Low to Moderate Creep	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
EROSION								
Active	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable
High Potential	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Conditionally Acceptable	Conditionally Acceptable	Conditionally Acceptable
Conditional Potential	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Minimal Potential	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

SAFETY HAZARD IDENTIFICATION AND REDUCTION

HAZARD IDENTIFICATION AND REDUCTION

This section will describe safety-related hazards such as seacliff retreat, fire, flooding, and dam inundation. Similar to the Seismic Safety chapters, the discussion will be divided into a general description of the hazard, effects of the hazard, local conditions, hazard reduction, and recommendations.

Seacliff Retreat

General Description

Seacliff retreat is a continual, natural process, through which the actions of various geologic, marine, and artificially induced processes can result in substantial losses of seacliff material. These processes often involve powerful natural forces that realistically cannot be completely neutralized by the action of man, and can be only partially controlled. Due to the perpetual nature of these erosion processes, and the resulting landward retreat of the seacliffs, these areas should be perceived as temporary features.

Measurements of the rate of seacliff retreat done by Norris (1968) indicate that bluff retreat can range from about three to ten inches per year, with eight inches being average. It should be noted here that these rates of retreat are average rates based upon accumulated losses over many years. It does not infer that eight inches of bluff will necessarily be lost each year. Bluff retreat can be a spasmodic phenomenon and occur more by slab or large block failure, involving large sections of bluff rather than constant annual losses.

The seacliffs in Santa Barbara are composed primarily of the Monterey Shale Formation. This formation is prone to rapid erosion and landsliding for several reasons:

1. It is a thinly bedded sedimentary rock in which the bedding plans frequently slope seaward. This will facilitate erosion from wave attack and allow the forces of gravity to pull the slope material downhill more easily than if the bedding planes were to slope away from the base of the cliff.

2. The presence of Bentonite clay layers adds to the inherent instability of the Monterey Formation. This highly expansive clay was formed from the weathering of volcanic ash layers buried within the rock. When the clay becomes wet, it will expand and become very slick, facilitating the downslope movement of the slope material above it.

3. This formation is often tightly folded, crumpled, and fractured. This allows the thin brittle rocks to be easily plucked away from the bluff face by wave action and deposited at the base of the bluff as a small pile of rock debris.

4. The abundance of bedding planes, joints, and fractures in the rock allows water to enter the formation in many places, reducing the overall rock strength.

Natural erosional agents are constantly at work, trying to degrade the seacliff. The erosion of the base of the cliff by direct wave action is a common process that can result in the undercutting of the cliff, thereby removing the support from the overlying layers of slope material. This process will greatly accelerate seacliff retreat. Rainwater and runoff flowing over the face of the cliff will accelerate erosion by cutting drainage depressions into the soft cliff material. Additional weathering and weakening of the rock results from the cliff being exposed to the salt spray of the ocean water.

Perhaps the most severe artificially induced erosional agent that can accelerate the retreat of the seacliff is the addition of water and a process called "spring sapping." Urban development along the cliff top is frequently accompanied by the planting and watering of lawns and gardens, the use of private sewage disposal systems, leaking underground pipes, etc. Such additional water on the bluff will percolate down into the ground and emerge at the base of the bluff as a spring or seep. The continual emergence of this water can significantly weaken the cliff material.

Other artificially induced actions that can increase seacliff retreat include:

1. Improper Access Routes - Foot traffic along the edge and down the face of the cliff can cut small paths that serve as water channels during rainstorms. These channels can cut gullies into the cliff material.

2. Loading - Increasing the weight placed on the top of the cliff with buildings, fill, swimming pools, etc., can make a formerly stable slope unstable.

3. Plant Growth - Plants that overhang the bluff and grow on the bluff face which are heavy and have shallow root systems (usually non-native plants, such as ice plant, etc.) can actually act to pull the slope material downhill.

Effects of the Hazard

Unless rapid, massive movements of seacliff material occur, the slow, continuous process of seacliff retreat may go unnoticed until the long-term effects of the losses are observed. Houses, drainpipes, fences, patios, etc., that are now overhanging the edge of the cliff reveal the almost imperceptible, yet constant, retreat of the cliff. The eventual fate of these structures is certain.

When large, rapid movements of cliff material do occur - often in response to heavy rains - lives, structures, and valuable property located along the cliffs may be lost.

Local Conditions

As mentioned earlier, all of the seacliffs in Santa Barbara are experiencing active erosion and retreat. Due to local variations in the strengths of the material that comprise the seacliff, bedding plane orientation, and the adverse effects of development and human interference, some areas are experiencing more rapid erosion and retreat than others.

Active erosion (gullying and sedimentation active during the winter months) and historically active landslides can be observed on the cliffs below the Mesa, extending from Santa Barbara Point westward to the city limits. Active erosion is also taking place along the bluffs of the Clark Estate, near the eastern city limits. The seacliff maps (Figures 5a, b, and c) all show areas of active erosion, landslide activity, and geologic features.

Hazard Reduction

Four possible methods of attempting to mitigate the hazards associated with seacliff development include:

1. Establish adequate building setbacks for new development from the edge of the cliff.

2. Install systems to collect, control, and dispose of water deposited on the cliff.

3. Eliminate hazardous practices that accelerate the rate and severity of seacliff retreat.

4. Construction of cliff and shoreline protection devised to diminish the impact of ocean waves.

Recommendations

1. New development on the top of the cliff shall be placed at such distance away from the edge of the cliff that normal rates of erosion and cliff material loss will not seriously affect the structure during its expected lifetime.

   Using the following simplified formula, a preliminary seacliff setback line has been devised (Hoover, 1978):

$$\text{Setback} = \frac{\text{height of the shale seacliff}}{\text{tangent of dip}} + (\text{thickness of terrace})(2) + (8''/\text{yr})(75\ \text{yrs})$$

This formula assumes that unsupported bedding planes are unstable, the average rate of seacliff retreat is eight inches per year, terrace deposite (soil material deposited on top of the shale) stabilizes at a 2(H):1(V), and the design life of the project is 75 years. This preliminary setback line is depicted on the seacliff maps.

This setback is only a preliminary line and must be verified on a site-specific investigation of the property in question by a registered geologist.

2. As discussed earlier in this section, the addition of water to the seacliff can significantly lower inherent cliff stability and cause a stable cliff to become unstable.

   a. Erosion caused by rainwater collecting on the top of the seacliff and then running over the edge can be minimized by installing lateral or "French" drains to collect and control the water. The water can then be piped off the property and properly disposed of in storm sewers. New development shall be required to install some satisfactory means of removing water from the cliff top. Owners of existing structures should be encouraged to install their own drainage devices to protect their homes and property.

b. To prevent excess water from being applied to the top of the cliff for gardening purposes, the planting of lawns, gardens, etc., should be discouraged. Instead, a native vegetation that is drought resistant, and that has deep, strong root systems to aid in stabilizing the cliff material should be planted. A list of drought-resistant native vegetation is included in Appendix 6. Most of these plants will grow rapidly but are small or medium in size, so as not to obstruct views.

3. In an attempt to impede the cliff retreat process, programs to control or prohibit the following activities that can significantly alter the rates of seacliff erosion and retreat shall be implemented.

a. Improper Access - Improper access may be discouraged by providing existing, established official beach access routes with additional parking, improved access facilities, and publicizing their locations. The use of unmaintained, improvised access routes that have the potential or are creating a serious erosion problem should be discouraged. This could be done by posting informational signs at the top of cliff near the access route, describing the adverse effects that improper access can cause and where the nearest maintained access routes are located.

b. Loading - Development that will add adverse amounts of excessive weight to the top of the cliff (i.e., large structures, swimming pools, artificial fill, etc.) shall be discouraged.

c. Improper Vegetation - Where feasible, existing non-native vegetation that requires large amounts of water, such as ice plant and annual grass, shall be replaced with native vegetation.

d. Trash Disposal - The disposal of any material onto the face of the cliff, including brush clippings from landscape vegetation, shall be prohibited.

4. To protect seacliffs and the structures placed on them from erosion caused by wave action, retaining walls, sea walls, broken concrete or stone revetment, breakwaters, and groins are sometimes used. Before the construction of these or any other shoreline protection structure is allowed, the need and potential for adverse environmental impacts of the project shall be evaluated by appropriate engineers as designated by the Building Official.

LEGEND

GEOLOGIC UNITS

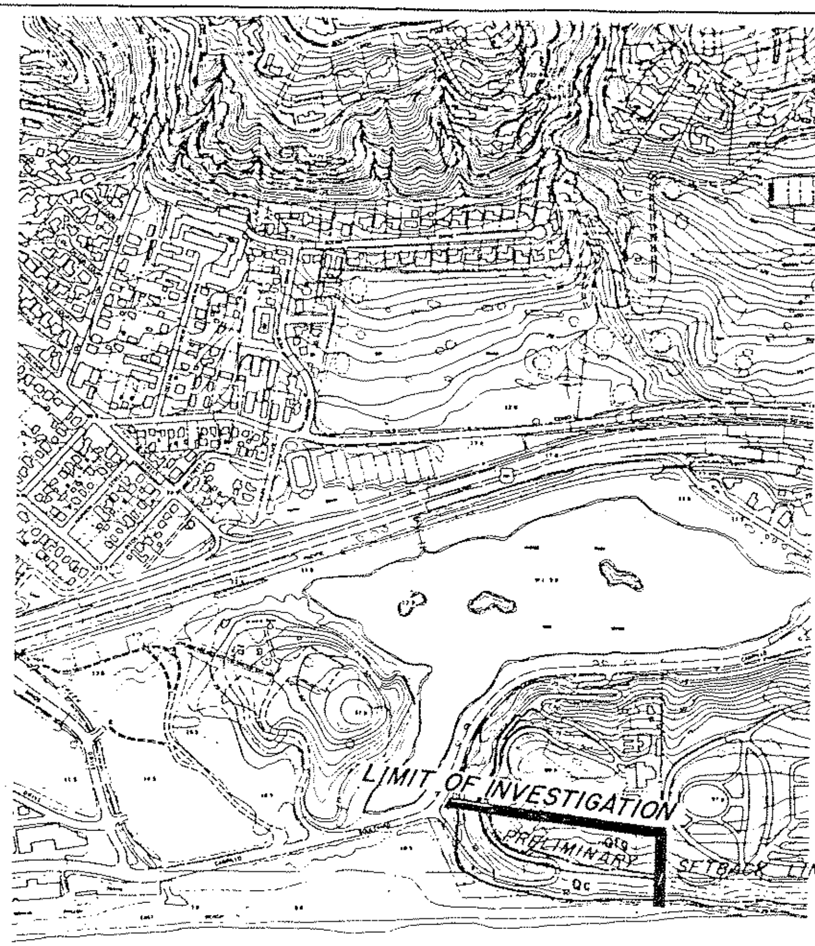
Symbol	Description
Qaf	Artificial Fill
Qls	Landslide
Qal	Alluvium
Qt	Terrace Deposit
Qc	Casitas Formation
Tm	Monterey Shale

SYMBOL

- Limit of Investigation
- Prelim. Setback Line
- Contact between formations
- Fault
- Anticline
- Syncline
- Fractured Bedding
- Landslide. Arrows indicate direction of movement.
- 69 Strike and dip of bedding
- Strike of vertical bedding
- Overturned anticline
- Overturned syncline

Notes:

1. Geologic contact not always shown in order to preserve clarity. Bluff face is generally Monterey Shale (Tm), Mesa is generally 6 to 20 feet thick terrace deposit (Qt).
2. For complete description of geologic units and symbols on Coastal Hazards Maps see Plate 1.



A N

0 600' 1200' 1800' 2400'

Scale: 1 Inch = 600 Feet

Figure 5A

THE CITY OF
SANTA BARBARA
COASTAL HAZARDS MAP
GEOLOGIC STABILITY OF BLUFF

MICHAEL F HOOVER
Consulting Geologist

Prepared for:
Santa Barbara Environmental Quality Advisory Committee
Joan Kerns, Chairman
according to specifications provided by the
SB EQAC Geological Ad Hoc Committee
William A. Anikouchine, Chairman

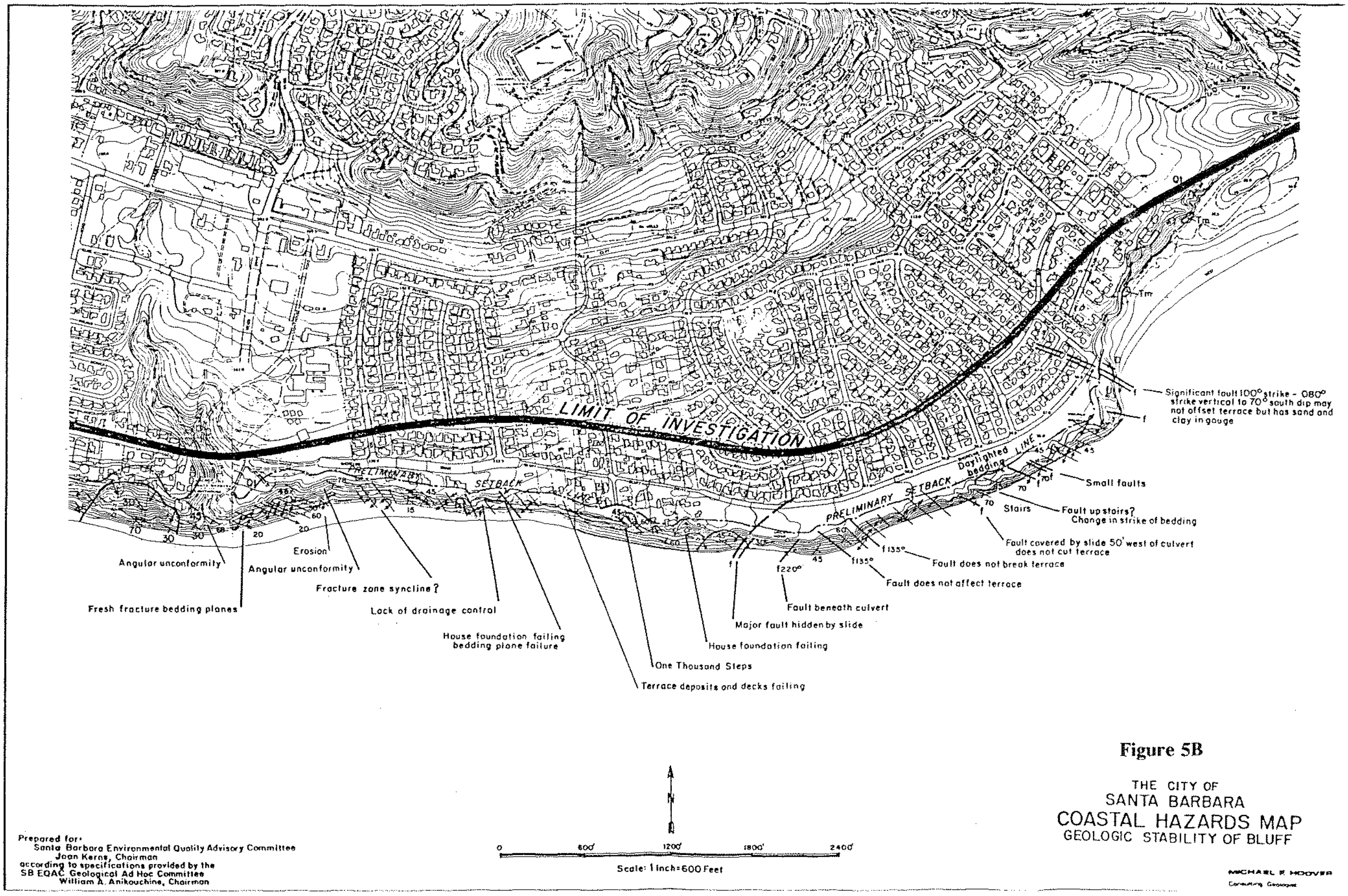


Figure 5B

THE CITY OF SANTA BARBARA
COASTAL HAZARDS MAP
GEOLOGIC STABILITY OF BLUFF

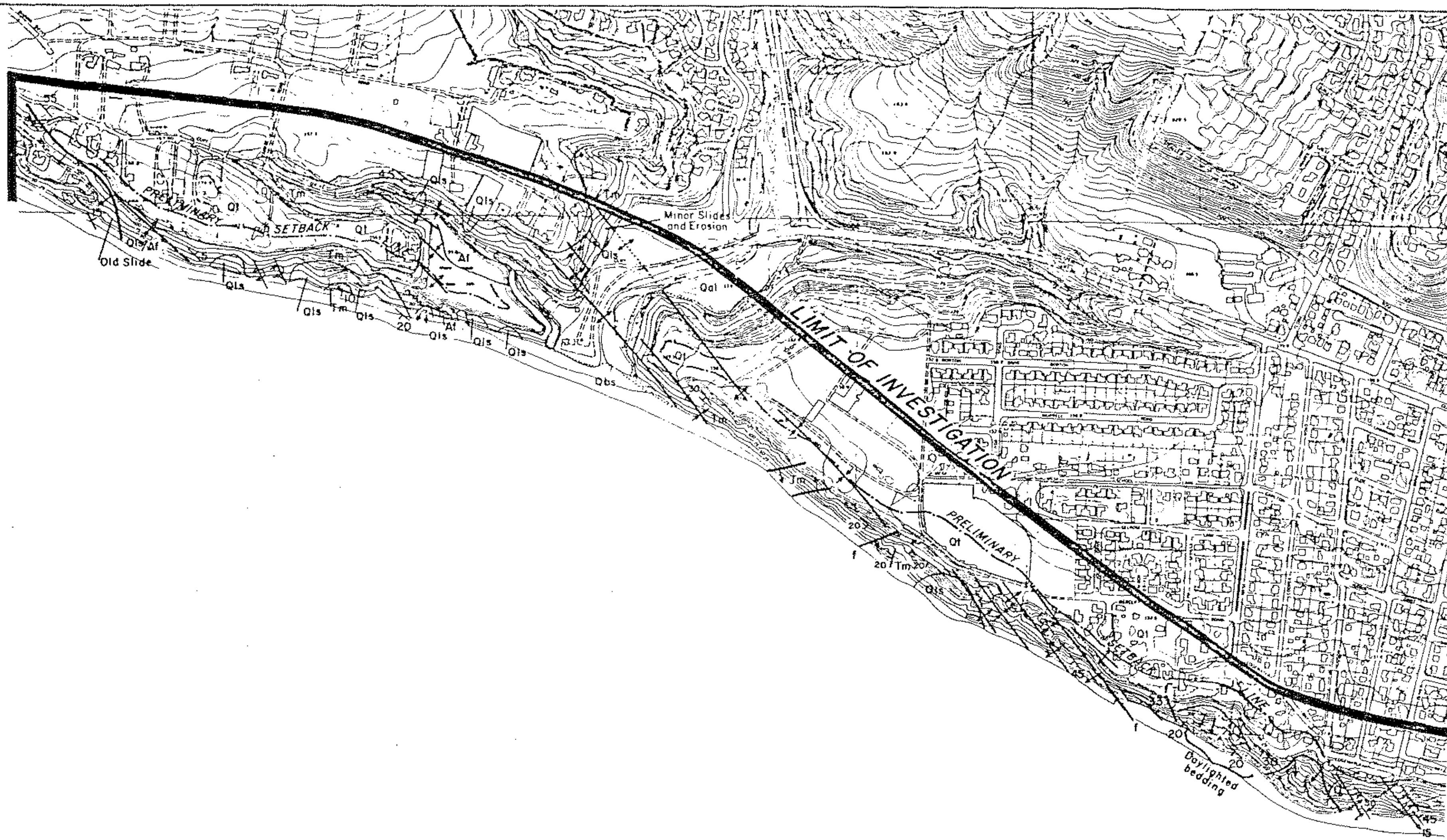


Figure 5C

THE CITY OF
SANTA BARBARA
COASTAL HAZARDS MAP
GEOLOGIC STABILITY OF BLUFF

0 600' 1200' 1800' 2400'
Scale: 1 Inch = 600 Feet

N

Prepared for:
Santa Barbara Environmental Quality Advisory Committee
Joan Kerns, Chairman
according to specifications provided by the
SB EQAC Geological Ad Hoc Committee
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MICHAEL F. HOOVER
Consulting Geologist

File 142-001

By K. Frost Date 10-18-78

Fire

History of the Hazard

The potential for a serious wildfire in Santa Barbara was fully realized in 1977 with the Sycamore Canyon fire. Fanned by Santa Ana winds gusting at times over 50 miles an hour, the fire burned out of control for over 36 hours. When it was finally extinguished, over 800 acres were blackened, 216 homes were destroyed and another 64 damaged, more than one million dollars were spent to combat the blaze, and property damage losses from the fire exceeded $30 million. In light of the high amount of damage caused by the fire, it was lucky there were no fatalities. The fire burned most fiercely inside the city limits, destroying 141 homes and damaging another 41. The destructiveness of the fire was demonstrated by the fact that 77 percent of all homes touched by it burned to the ground.

Suppression of the fire was hampered from the beginning by high, erratic winds, high temperatures, extremely low humidity and fuel moisture, and the old age and density of the brush that was burning. (Some of the burned brush areas had been last burned in 1889.) The mixing of houses in and around areas of heavy fuel accumulations made it difficult to protect homes, and houses with wood-shake and shingle roofs that ignite easily also aided in spreading the flames. Fire suppression was made difficult because of the narrow roads leading into the fire area, as heavy congestion was created by the fire trucks trying to get into the fire area and residents trying to get out. Fire suppression attempts were also hampered in the early stages of the fire by a lack of water pressure at fire hydrants due to the failure of the electric power needed to operate water pumps, and homeowners below the fire using hoses to water down their roofs.

The last large fire to affect Santa Barbara had been the 1964 Coyote fire. This fire burned for 13 days and blackened 67,000 acres in the hills behind Santa Barbara. The Coyote fire destroyed 48 structures, and damages were placed at $23 million. The most recent major fire to affect the South Coast, prior to the 1977 Sycamore Canyon fire, was the 1971 Romero Canyon fire. This fire burned for ten days in the hills behind Montecito and Carpinteria. Four firefighters died fighting the blaze, and many were injured. Total damages were $3.3 million, and 16,000 acres were burned.

General Description

Every summer Santa Barbara residents are confronted with a unique and extremely hazardous wildfire problem. On dry, windy summer days, grass, brush, woodland, and chaparral communities become virtual tinder boxes that can be easily ignited. These volatile conditions are created by Santa Barbara's Mediterranean climate which is characterized by warm, mild temperatures year-round, with most of the rainfall concentrated during the winter months, and a drought condition persisting throughout the summer. The absence of summer rainfall causes vegetation to become dangerously dry.

A climatic condition that will aggravate an already dangerous summertime fire potential, in Santa Barbara as well as the rest of southern California, is the occurrence of Santa Ana winds. Normal wind flow is reversed, and instead of cool, moist ocean breezes blowing onshore, hot, dry air pours in from the north and east out of the deserts. These dry winds desiccate vegetation already dried by summer drought and serve to aggravate a burning fire by fanning and spreading flames.

The potential for a severe wildfire to occur is increased when dense vegetation growth and large accumulations of plant material are present. This potential is increased even further when a brush area has not been burned within approximately 30 years, and the percentage of dead plant material exceeds 30 percent of the total vegetative growth present (Cahill & Perry, 1978). Steep terrain can also serve to compound wildfire risk, as fires will normally burn much faster uphill, and rugged terrain will also hinder fire suppression attempts by hampering the mobility and effectiveness of firefighters and equipment.

Causes of Wildfire

Severe weather conditions, dense vegetation, and steep terrain can all create a hazardous wildfire potential; however, these conditions do not <u>cause</u> wildfires. It has been estimated that over 90 percent of all wildfires are caused by human carelessness. Other estimates show that over one-third of all wildland fires originate alongside roads and highways, probably as a result of cigarettes or matches being thrown from passing automobiles. Despite rising penalties, approximately 22 percent of all fires recorded statewide result from the act of arson.

High voltage power line failure is another potential source to start wildfires. Approximately 23 percent of all the wildfires that burn over 5,000 acres are caused by power line failure. Since 1960, 11 fires in the Santa Barbara Front have been started by high voltage lines (Ensign, 1978). Other causes of wildfire include such activities as debris burning and machine use (i.e., off-road vehicles, construction equipment, and other power-driven equipment used in industry, agriculture, and recreation). Wildfires also originate in developed areas, as children playing with matches, bonfires, rubbish burning, sparks from chimneys, and fireworks are often cited as sources of wildfire.

It should be noted here that wildfire in southern California is a natural, recurring, necessary event. Native vegetation has developed adaptations to survive repeated burning and has, in fact, grown dependent on it. Some species of plants must be burned regularly or they will become senescent and die after about 50 years. The reasons for this are not well understood, but it is thought that in some cases toxic chemicals produced by the plants reach concentrations in the soil higher than the plant can tolerate.

To survive these frequent burnings, many chaparral plants have developed adaptations that allow them to grow back quickly after a fire. Such adaptations include a root system that can tolerate extreme heat and will quickly resprout, and seeds that require extremely high temperatures before germination can occur.

Effects of the Hazard

<u>Immediate</u> - Immediate losses resulting from wildfire generally have the most impact on the natural environment. Although some ecosystems are dependent upon recurrent fire to survive, these communities are unique. Damage to man-made structures usually accounts for most of the monetary losses caused by wildfires. Other losses result from the immediate fire suppression costs, the loss of watershed, wildlife, recreation areas, and public service facilities such as telephone and electrical lines. Wildfire can also jeopardize the lives of residents in its path and the lives of men and women attempting to put out the fire.

Short-Term - After the fire has been extinguished, the burned land is laid bare of its protective vegetation cover and is susceptible to excessive runoff and erosion. The fire will often destroy the root systems of shrubs and grasses that aid in stabilizing slope material. When the winter rains come, the possibility of severe landslides and mudslides is greatly increased.

Public utilities are often strained by the impacts of wildfire. Water reserves are depleted, power lines are downed, telephone service can be disrupted, roads can be blocked, etc. Flood control operations may be affected by an increase in storm runoff, sediment and debris, resulting from barren, burned-over hillsides.

Long-Term - The long-term effects of a fire on a natural community are usually limited. If a grassland is burned, it will resprout with the first rain; a chaparral community will regenerate in three to five years; a woodland will take longer to achieve a comeback, but is still within a five to ten-year range. The most significant long-term effect of a wildfire will be felt in coniferous timber stands that may take over 100 years to reestablish themselves.

Local Conditions

The steep, rugged terrain to the north of Santa Barbara, up to the crest of the Santa Ynez Mountains and west to Gaviota, is referred to as the Santa Barbara Front. Although this area extends well beyond the Santa Barbara city limits, a major fire here has the potential to directly or indirectly affect Santa Barbara, and should, therefore, be of concern. A number of areas within the City of Santa Barbara have been designated as High Fire Hazard Zones. As shown in Figure 7, these areas are within the Mesa, Riviera, Cielito, Eucalyptus Hill, Foothill, Bel-Air, Hidden Valley, and Campanil neighborhoods. These areas have been designated as having a high fire hazard for several reasons, the most important being that these are predominantly brush areas and present a high summertime fire potential. Other criteria used to delineate these areas include difficult access, hilly terrain, and low water pressure.

Of all the neighborhoods designated as High Fire Hazard Zones, the Riviera, Cielito, Eucalyptus Hill, and Foothill areas have the greatest potential to experience a large, rapidly moving wildfire. Mission Canyon, which lies just to the north of the city limits, between the Cielito and Foothill areas, has been designated by the Santa Barbara Fire Department as the most probable site of the next major blaze in Santa Barbara. Much of Mission Canyon is hilly and overgrown with thick stands of old vegetation, and many residents do not have adequate brush clearances around their homes. Suppression of a major fire in Mission Canyon could be made difficult by inadequate access in and out of the canyon and the lack of adequate places for firefighters to make a stand in an attempt to fight the fire. Under the right conditions, a fire could sweep rapidly through Mission Canyon and move into the city limits (Robinson, 1978).

The other High Fire Hazard Zone areas in the City - the Mesa, Bel-Air, Hidden Valley, and Campanil areas - are brush areas that have the potential to experience a serious fire. However, there is no historical problem of large, severe fires occurring in these neighborhoods. Most of the fires that do occur here are spot fires involving single structures.

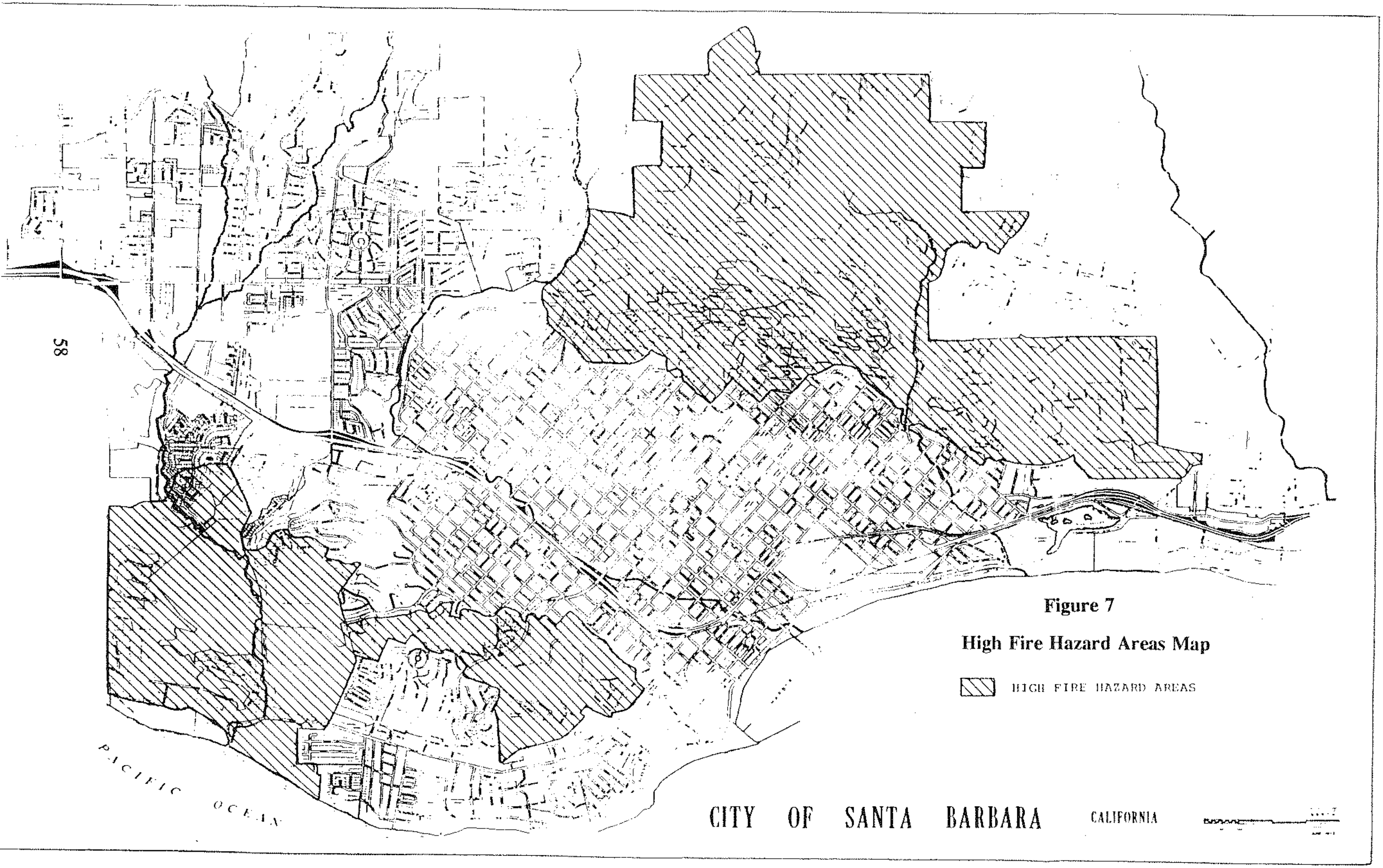

Figure 7

High Fire Hazard Areas Map

Hazard Management

Fuel Management - The four principal factors that affect wildfire most directly are weather conditions, topography, people, and fuel. Of these, only fuels can be readily influenced.

Several methods may be employed to manipulate the accumulation of wildfire fuels. One common method is the use of fire breaks, or areas cleared of all flammable vegetation, usually along ridgetops. Unfortunately, fire breaks are rather stark in appearance and are susceptible to erosion.

Effective fuel management may also be obtained by the use of fuel breaks. These are areas where the vegetation is selectively thinned to decrease the density of fuel accumulation and the intensity at which the fire will burn. Fuel breaks, however, are more expensive to create and maintain than fire breaks. Fuel breaks have been used in Santa Barbara County along Camino Cielo, after the 1964 Coyote fire.

Another common method of fuel management is controlled or prescribed burns. The purpose of controlled burns is to burn areas of the highest hazard during the safest times of the year, in hopes that future uncontrolled blazes can be avoided. The largest problem with prescribed burns is that once the fire has been ignited, it is never truly "under control." The use of controlled burns for fuel management purposes is currently not allowed in Santa Barbara County.

Minimum Road Widths - Public roads in Santa Barbara must have a minimum of a 40-foot-wide dedication and a 32-foot-wide road. A 35-foot radius is required for all cul-de-sacs. Many roads, especially in the Riviera, Cielito, Eucalyptus Hill and Foothill areas, are old roads and are much narrower than the 32-foot minimum. This makes access for fire fighting equipment into those areas difficult, and in some isolated areas, almost impossible.

Peak Fire Flows - The maximum water supply required for completely extinguishing a fire involving any structure can be calculated by using a complex formula that takes into account the building type, building construction materials, square footage of the building, contents of the building, and the surrounding terrain. Generalized fire flow requirements are shown in Table 5.

In Santa Barbara, the estimated maximum fire fighting flow from fire hydrants is approximately 2,200 gallons per minute (GPM). This leaves some hotel and industrial areas with slightly deficient water pressure to fight a fire involving the entire or more than one structure. Fire flow water pressures will be lower in the higher elevations of the City.

Warning and Evacuation - In the event of a major wildfire, owners of homes and inhabitants of communities threatened by fire are so warned and advised to evacuate. The responsibility for implementing warning and evacuation operations within the city limits is a function of City Police. Formal evacuation routes are not predetermined due to the unpredictability of wildfires; evacuation routes will be determined in accordance with the conditions at the time.

TABLE 5
FIRE FLOW REQUIREMENTS

Area Classification	Fire-fighting flow, GPM	Duration of flow, hrs.	Volume of Water required mil. gal.
Residential			
Single-family units[1]	1,500	6	0.5
Multiple-family units	2,000	8	1.0
Apartments	2,500	10	1.5
Hotel complex	3,000	10	1.8
Commercial			
Central business district	6,000	10	3.6
Regional shopping area	3,500	10	2.1
Neighborhood shopping area	2,500	10	1.5
Industrial[2]	3,000-5,000	10	1.8-3.6
Elementary Schools	2,500	10	1.5
Secondary Schools and Hospitals	3,000	10	1.8

[1] Minimum design flow regardless of projected land use.

[2] Required flow varies with size and type of structure and on-site protection facilities.

Suppression

The City of Santa Barbara Fire Department has the responsibility for fire suppression within the city limits. If additional support is needed in fighting a major fire, the City has mutual-aid agreements with Santa Barbara County, Carpinteria, and Montecito. Other jurisdictions can be called on for assistance from as far away as the help is needed. During the 1977 Sycamore Canyon fire, units were called in from as far away as Los Angeles.

The City also has a mutual-aid agreement with the U.S. Forest Service. Santa Barbara firefighting forces will aid in fire suppression on National Forest land if the fire poses an imminent danger to the city limits.

Recommendations

Development Controls

1. Require that all land development proposals in the High Fire Hazard Zones be accompanied by detailed plans for fire prevention and control measures, prepared in accordance with City regulations. These plans shall be received by the City Fire Chief, Building Official, and other appropriate agencies.

2. Average road grades for new development shall not exceed 16 percent in order to facilitate access by emergency vehicles.

3. Construct turnouts on roads in the High Fire Hazard Zones every 1,000 yards to improve firefighting.

4. Install approved fire hydrants at 500 foot intervals along roads.

5. Strictly enforce the special building provisions for fire safety and prevention in the High Fire Hazard Zones.

6. Encourage homeowners in High Fire Hazard Zones with low water pressure to install their own emergency water supplies for firefighting operations. This could be swimming pools, water storage tanks, or other acceptable facilities.

Fuel Management Controls

7. Encourage the U.S. Forest Service to put highest priority on fuel management programs in areas of their jurisdiction near the city limits.

8. Encourage and promote the planting of orchards on the margins of High Fire Hazard Zones as productive fuel breaks.

9. When feasible, comprehensive fuel management programs shall be instituted in High Fire Hazard Zones within the City.

10. Minimum brush clearance provisions in the High Fire Hazard Zones shall be strictly enforced. Where applicable, measures shall be taken to reduce the threat of spreading flames wherever fire-hazardous trees (eucalyptus, gum) are planted near structures.

11. Review existing ordinances and amend if necessary to require new developments in High Fire Hazard Zones to use fire-resistant planting in landscape plans.

Other

12. Encourage and promote the planting of fire retardant plants throughout the High Fire Hazard Zones in the City.

13. Periodically review and, if necessary, revise the High Fire Hazard Zone Maps to reflect new data regarding vegetation age and density.

14. Review and amend the Circulation Element of the General Plan to insure that emergency access routes for new subdivisions are adequate to allow fire and other emergency service vehicles to gain access.

All of the above recommendations should be subject to review and, as deemed necessary, be amended in accordance with the City's Fire Master Plan.

Flooding

History of the Hazard

Floods are relatively frequent occurrences in Santa Barbara. Since 1862, a damaging flood has occurred approximately once every seven years.

One of the greatest floods ever to strike Santa Barbara occurred in 1862 when it rained consistently for five weeks, between December 24, 1861 and January 31, 1862. As a result of this deluge, the face of the Santa Ynez Mountains was permanently changed by extensive erosion. The sediment produced by the rains washed down and filled in what had previously been a deep water port used by ocean-going vessels to form the Goleta Slough.

Torrential rains in 1914 destroyed six bridges, 12 houses, several commercial establishments, and dozens more were damaged. Some paved streets were turned into channels and eroded into gullies ten feet deep. In one 48-hour period, 9.36 inches of rain fell.

More recently, the last serious flooding to occur in Santa Barbara was in 1967. Serious erosion took place along Arroyo Burro Creek near La Cumbre Golf Course. An estimated 10,000 cubic yards of debris was deposited in emergency debris basins on San Roque and Mission Creeks. Major bank overflow took place at the bridges of U.S. Highway 101 and the adjacent railroad. Overflow extended eastward from Mission Creek and mud was deposited near the train depot. Numerous commercial establishments several blocks from Mission Creek were damaged by the flood. Many homes on the west side of Mission Creek were flooded and several large motels on the ocean front were damaged. Sycamore Creek overflowed just upstream of U.S. 101, inundating the Municipal Tennis Courts under approximately 1.5 feet of water and mud.

In January 1969, the worst floods in the history of Montecito and Carpinteria occurred causing vast amounts of damage. Only minor overflows were experienced in Santa Barbara.

General Description

A flood may be defined as a temporary rise in stream flow that results in water overtopping its banks and inundating areas adjacent to the channel not normally covered with water. The relatively flat or lowland area adjoining the stream that is subject to periodic inundation by floodwater is known as the floodplain.

The magnitude of a flood is measured in terms of its peak discharge, which is the maximum volume of water (in cubic feet per second) passing a point along the channel. Floods, however, are usually referred to in terms of their frequency of occurrence. For example, the 100-year flood is a certain flood magnitude which has a one percent chance of being equaled or exceeded in any given year. There is a certain element of risk involved using this type of designation, however, as the prediction of a flood of a particular magnitude is based on probability and an element of chance is involved. According to statistical averages, a 25-year flood should occur on the average once every 25 years, but two 25-year floods could conceivably occur in any one year. For planning purposes, the flood magnitude most often used in delineating flood plain boundaries is the 100-year flood. This flood is also referred to as the "intermediate regional" or "base flood."

Flooding is basically a direct response to the amount, distribution, and intensity of precipitation. Most storms are relatively small and do not seriously disrupt people and the land on which they live. Occasionally, however, a storm of great magnitude will occur, causing serious damage and disruption to the landscape and its inhabitants. This relationship between great storms and their rates of occurrence is known as the Magnitude-Frequency Concept. The magnitude of an event refers to its size (the height of flood waters) and the frequency refers to the number of times a given event occurs during some specified time period. Fortunately, magnitude and frequency are inversely related; that is, events of great magnitude and force occur infrequently, and vice versa.

Flooding is a naturally occurring event with some long-range beneficial aspects, such as the replenishment of beach sand and nutrients to agricultural lands and the ocean. Flooding has come to be perceived as a "hazard" because people have found floodplains are flat fertile lands, making them convenient and desirable places to live. A dangerous misconception about the flooding hazard is often held by people who accept the old expression "lightning doesn't strike in the same place twice." There is an assumption made here that once a major flood (such as a 50-year or 100-year flood) has been experienced, the area flooded is "safe" for another 50 or 100 years. Often, in areas where rapid urban development is taking place, quite the opposite holds true, the potential for more frequent floods is created. As mentioned earlier, flood probabilities are based on chance, and are therefore not infallible.

Effects of the Hazard

The extent of damage caused by any flood depends on the topography of the area flooded; depth and duration of flooding; velocity of flow; rate of water rise; the extent of development and land use on the floodplain; the sediment load deposited by the flood; and the effectiveness of forecasting, warnings, and emergency operations.

Primary effects of flooding include injury and loss of life; damage to structures caused by swift currents, debris, and sediment; disruption of communication and transportation facilities; severe erosion; loss of vegetation and crops from sediment deposition; health hazards from ruptured sewage lines and damaged septic tanks; and the disruption of utilities and vital public services.

Secondary effects of flooding place a burden on local and national taxpayers and resources. Evacuation relief and floodfighting services, clean-up operations and the repair of public facilities are paid for by the public. The construction and maintenance of flood prevention and control facilities are also paid for by taxpayers.

Influences on Flooding Impacts

The magnitude and frequency of flooding events can be influenced by many factors. Natural and artificially induced changes of the characteristics of the drainage basin and floodplain of a stream can have profound effects on the extent and severity of any particular flood.

The growth of brush and trees within the floodplain can act as natural obstructions to floodwater flow by creating a backwater effect and increasing floodwater heights. Flood heights may also be naturally increased by the occurrence of fire in a watershed preceding heavy rainfall, resulting in an increase in storm runoff and sediment production; and by previous rainfall saturating the ground, thus decreasing its ability to absorb additional moisture.

Perhaps the most serious artificially induced change in drainage basin and floodplain characteristics that can influence the magnitude and frequency of flooding is the encroachment of urban development. Urbanization often leads to a greater percentage of impervious ground surface (i.e., pavement, concrete, rooftops, etc.) which tends to increase the total volume of storm runoff by decreasing the amount of water that infiltrates into the ground. Impervious surface material will also decrease the time lag between when the rainfall hits the ground and when it collects to be carried away by streams, storm sewers, etc. The combined effect of increased runoff and a decrease in lag time will cause more frequent and severe floods. Urban encroachment can also result in structures, artificial fill, and other objects being placed on the floodplain. This will act to reduce the space available for storing floodwaters, causing the water level and rate of flow to increase. Bridges and other stream crossings also serve as flow obstructions as brush, trees, and other debris may be washed away and carried downstream to collect on bridges. As floodflows increase, masses of debris may break loose, sending a wall of water surging downstream; or the debris may have a damming effect until the pressure of the water exceeds the structural capability of the bridge and washes it away.

To protect urban development from the impacts of flooding, stream channels are often channelized (straightened, lined, etc.) to move the water off the land more efficiently. However, when water emerges from the improved section of stream channel, it is often delivered to the unchannelized downstream section at rates and velocities the natural section of stream is not capable of adequately carrying. Piecemeal channelization efforts often exacerbate the flooding potential downstream.

It is important that flood hazard reduction operations be comprehensive, well-planned programs. If they are not, they may create a false sense of security from floods in the community that will allow new development or the expansion of existing facilities in areas that are still subject to flood risks.

Local Conditions

The City of Santa Barbara is subject to periodic flooding from Sycamore, Mission, Arroyo Burro, and San Roque Creeks. Of these, Mission Creek poses the most significant flooding hazard (Dossey, 1978). The Santa Barbara Municipal Airport located nine miles east of Santa Barbara in the Goleta Slough, is subject to inundation from San Pedro, Las Vegas, Carneros, and Tecolotito Creeks. All of these streams originate in the Santa Ynez Mountains to the north of the City and flow south through alluvial fans to the ocean.

Water flow in these streams is negligible, except during and immediately after rains as local climate and drainage basin characteristics are not conductive to continuous stream flow.

Flood waters in Santa Barbara could cover wide areas of relatively flat land, much of it highly urbanized. The maps showing areas that are subject to inundation by the 100-year flood are referenced in the Conservation Element. These flood boundaries derived from the final maps compiled by the Department of Housing and Urban Administration Development (1978) for the Federal Insurance to implement the National Federal Flood Insurance Act of 1968. The major drainage areas within the City are as follows:

Central Drainage Area - The watershed area between Mission and Sycamore Creeks, approximately 1,600 acres, is known as the Central Drainage Area. Due to inadequate local drainage, there is frequent flooding of this highly urbanized area (U.S. Army Corps of Engineers, 1975).

Mission Creek - Mission Creek runs for 4.4 miles across the City, from the northern city limits at Mission Canyon through the Eastside and Oak Park neighborhoods, then turns east to flow parallel along U.S. 101 until it meets the ocean near the foot of State Street. The stream channel has been straightened between Pueblo and Gutierrez Streets, north of U.S. 101, and portions have been lined with concrete. A debris basin has been constructed on the upper reaches of Mission Creek, but it is small and would have no effect on regulating the size of a large flood (HUD, 1977).

Mission Creek is a good example of a stream that has been surrounded and modified by intense urban development pressure. The current location of the stream channel has been altered for economic considerations, and not for maximum efficiency in carrying water. This situation has been created by streambank residents who push the stream out along property lines to prevent it from running through their property. This has created turns and shifts of direction in the stream that would not naturally occur and which act to slow down the flow of floodwater.

A "precise-alignment" study conducted along Mission Creek as it flows through the City would provide an accurate determination of where the stream would flow naturally, how to best improve the stream channel configuration so that it will carry water most efficiently, and would create adequate creek setbacks that would provide protection to creekside structures and other areas downstream.

The 100-year floodplain for Mission Creek will cover extensive areas of residential and commercial property. Flooding above the outer State Street area is mainly confined to the vicinity near the stream channel. South of State Street the floodplain widens, and below U.S. 101, flows separate from the stream channel and covers much of the Westside between U.S. 101 and the Mesa. Additionally, much of the lower downtown area between Gutierrez and Santa Barbara Streets extending to the beachfront, and another 12-block area between Ortega and Quarantina Streets and the freeway is subject to inundation by the 100-year flood.

Sycamore Creek - Sycamore Creek extends for 2.7 miles through the Cielito, Riviera, Eucalyptus Hill, and Eastside neighborhoods southward to East Beach and the ocean.

Much of the land adjacent to Sycamore Creek has been developed and is exposed to a flooding hazard. This has led to a situation where homeowners have attempted to implement their own flood control measures, often consisting of structures or material improperly placed on the creek bank in an effort to contain floodwaters. These measures, however, create a false sense of security, as they are often undermined by floodwater and end up falling into the creek (Dossey, 1978).

Flooding along most of Sycamore Creek is confined to the stream-channel and the adjacent area until it crosses Carpinteria Street where a 100-year floodflow would begin to widen. South of U.S. 101 much of the Andree Clark Bird Refuge, East Beach, and the Child's Estate could be inundated.

Arroyo Burro Creek - Arroyo Burro Creek flows for 4.5 miles from the northeastern city limits to the ocean at Arroyo Burro Park.

The 100-year floodplain for Arroyo Burro Creek in the area above outer State Street is confined to a narrow stream channel. Just below State Street, where San Roque Creek merges with Arroyo Burro, floodflows become separated from the channel and could inundate much of the Hidden Valley area. Further downstream, floodflows will return to the vicinity of the stream channel and remain there until the stream meets the ocean.

San Roque Creek - San Roque Creek flows for 1.2 miles between Foothill Road and its confluence with Arroyo Burro Creek just south of State Street near Hope Avenue. A 100-year floodflow on San Roque Creek would remain in the existing narrow stream channel. Floodwaters would merge with Arroyo Burro Creek as mentioned above.

Airport Area - San Pedro and Las Vegas Creeks flow just to the east of the Santa Barbara Municipal Airport in a single channel. Tecolotito and Carneros Creeks merge in the Goleta Slough west of the airport. A 100-year flood on these four creeks would inundate the entire airport facility and the remainder of the Goleta Slough.

Recommendations

1. Establish and enforce adequate creek setbacks or buffer zones to protect new development from flood and erosion hazards.

2. Conduct "precise-alignment" studies along Mission and Arroyo Burro Creeks to determine the most efficient stream channel configuration and setback distances. Any improvements resulting from the studies should be reviewed as to consistency with the Conservation Element.

3. To assure the effectiveness and structural integrity of flood containment structures placed on private land, all such construction should be subject to the approval of the Santa Barbara County Flood Control District.

4. Encourage light intensity use in the floodway or floodway fringe with the requirement that such uses shall not impair the flood-carrying capacity of the stream.

5. Develop a program to require removal or methods to effectively tie down floatable objects (lumber, trailers, empty storage tanks, etc.) located on the 100-year floodplain.

Dam Inundation

General Discussion

Since potential dam failures affect the safety of many communities, inundation maps for all major dams are being prepared by the dam operators pursuant to Section 8589.5 of the Government Code of California. These maps will become a mandatory consideration in the Seismic Safety and Safety Elements when the maps have been approved by the State Office of Emergency Services.

These maps, however, are still in the preliminary stages of preparation and could be subject to change. This section will be added to the Seismic and Seismic Safety Element as soon as the final maps are available. The State does not require this section as part of the element until the final maps are received.

This hazard has a great deal of relevance to the City of Santa Barbara, as Lauro Canyon Reservoir is located just outside the City limits, and Sheffield Reservoir is within the City limits. Additionally, studies conducted by Hoover (1978) indicate that a fault may be located beneath Sheffield Reservoir or its abutments.

DISASTER PREPAREDNESS

The responsibility of coordinating and directing disaster relief operations for the City of Santa Barbara is a function of the Emergency Operations Center. This office has devised and maintains an up-to-date comprehensive Natural and Manmade Disaster Plan that outlines actions to be taken by key personnel of City staff in the event of a disaster.

This plan contains planning and operational checklists and guidelines for City disaster response departments such as Fire, Police, Public Works, etc., to assist them in formulating and executing their specific responsibilities before, during, and after a disaster. Also included in this plan are general standard operating procedures for all departments during all types of disasters, the functions of disaster support organizations (American Red Cross, Salvation Army, etc.) and special legislation addressing natural and manmade disasters.

A report on the August 13, 1978, earthquake to the State Seismic Safety Commission has indicated a number of problem areas in the City's disaster response capabilities. The problems, as discussed in this report, are as follows:

Emergency Power

The earthquake revealed problems and potential problems in backup power facilities for radio and television stations, the airport and hospitals. Radio stations are potentially the best way of conveying information to the public after a natural disaster. Yet, none of the Santa Barbara stations have emergency power at both the transmitter and the studio. The stations have considered backup power systems in the past, but cannot justify them economically unless outages are frequent.

At the airport, lack of backup power for the landing lights would have inhibited nighttime operations or operations during periods of low visibility. After a major natural disaster such as an earthquake, the airport would be a vital link with the outside world.

Medical Response

Although medical response to the earthquake was good, the event has caused hospital administrators to reexamine their ability to handle an event causing numerous serious injuries. It has been suggested that the County should designate a "Medical Regulator" who could oversee overall hospital response. Coordination between City and County officials and private hospital staff in emergency operations should be more clearly defined to facilitate smoother communications among hospital staff and between hospitals and the County disaster response operations.

Railroads

The California Division of Mines and Geology's report on the train derailment suggests the importance of the rails being checked after the earthquake, before trains are allowed to proceed. Had the derailed train been a passenger train, this earthquake would have been a catastrophe rather than merely an interesting event for engineers and seismologists.

Need for Earthquake Education

People do not often do the right thing during an earthquake, and often they do not know what to do afterward. This was manifested by a tendency in Santa Barbara for people to try to get out of the buildings they were in without due caution, and their lack of knowledge in handling the problem of gas leaking. As for actions during the earthquake, we do not know how much education can do to counteract what seems to be a natural reaction - to get out of the building. Even knowledgeable people in the public safety sector reported that their reaction was to get out fast. Nevertheless, education will do some good, especially if it is learning by doing, as in earthquake drills. Recommended procedures to be followed before, during, and after an earthquake are included in Appendix 7.

Recommendations

The City's Disaster Plan should be reviewed using the information provided by this report. Particular consideration should be given to upgrading emergency communications and self-sufficiency within the City of Santa Barbara. This could involve, but not be limited to:

1. Periodic earthquake and natural disaster drills conducted by the City and coordinated on a regional basis in cooperation with all involved jurisdictions.

2. Community programs that train volunteers to assist police, fire, and civil defense personnel during and after a major disaster should be established.

3. All present City operated emergency facilities (i.e., first aid stations, communication facilities, etc.) should be reevaluated as to their possible effectiveness in terms of location and response capabilities.

4. A review should be conducted of all emergency communication centers with respect to the availability of emergency power facilities now and in the future.

5. All major utility and transportation agencies should review the Seismic Safety and Safety Elements for possible impact on their facilities, and should forward comments to the City.

6. The City should develop an information release program to familiarize the citizens of Santa Barbara with the Seismic Safety and Safety Elements.

7. School districts and agencies related to aged, handicapped, and seismically susceptible industries should be encouraged to develop educational programs relative to seismic awareness. Appropriate private media for reaching different segments of the community (Spanish-speaking) should be established and presentations conducted. Builders and realtors in the City should be provided with the findings of this report.

8. The City's Disaster Plan should be reviewed and updated with respect to the transportation, handling and storage of hazardous materials; the location and potential hazards of nuclear facilities, liquid gas facilities, and other hazardous industrial facilities. Land uses adjacent to such facilities or major transportation corridors along which hazardous materials are shipped should be reviewed as to their compatibility and safety.

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APPENDIX 1

REPORT BOUND UNDER SEPARATE COVER

APPENDIX 2

Chapter 22.24

FLOOD PLAIN MANAGEMENT

Sections:

22.24.010 Findings of Fact.

A. The flood hazard areas of the City of Santa Barbara are subject to periodic inundation which results in loss of life and property, health and safety hazards, disruption of commerce and governmental services, extraordinary public expenditures for flood protection and relief, and impairment of the tax base, all of which adversely affect the public health, safety and general welfare.

B. These flood losses are caused by the cumulative effect of obstructions in areas of special flood hazards which increase flood heights and velocities, and when inadequately anchored, damage uses in other areas. Uses that are inadequately floodproofed, elevated or otherwise protected from flood damage also contribute to the flood loss. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.020 Statement of Purpose.

It is the purpose of the chapter to promote the public health, safety, and general welfare, and to minimize public and private losses due to flood conditions in specific areas by provisions designed:

A. To protect human life and health;

B. To minimize expenditure of public money for costly flood control projects;

C. To minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public;

D. To minimize prolonged business interruptions;

E. To minimize damage to public facilities and utilities such as water and gas mains, electric, telephone and sewer lines, streets and bridges located in areas of special flood hazard;

F. To help maintain a stable tax base by providing for the second use and development of areas of special flood hazard so as to minimize future flood blight areas;

G. To insure that potential buyers are notified that property is in an area of special flood hazard; and

H. To ensure that those who occupy the areas of special flood hazard assume responsibility for their actions. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.030 Methods of Reducing Flood Losses.

In order to accomplish its purposes, this Chapter includes methods and provisions for:

A. Restricting or prohibiting uses which are dangerous to health, safety, and property due to water or erosion hazards, or which result in damaging increases in erosion or in flood heights or velocities;

B. Requiring that uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction;

C. Controlling the alteration of natural flood plains, stream channels, and natural protective barriers, which help accommodate or channel flood waters;

D. Controlling filling, grading, dredging, and other development which may increase flood damage; and,

E. Preventing or regulating the construction of flood barriers which will unnaturally divert flood waters or which may increase flood hazards in other areas. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.040 Definitions.

Unless specifically defined below, words or phrases used in this Chapter shall be interpreted so as to give them the meaning they have in common usage and to give this Chapter its most reasonable application.

A. APPEAL. A request for a review of the Chief of Building and Zoning's interpretation of any provision of this Chapter or a request for a variance.

B. AREA OF SHALLOW FLOODING. An area designated AO, AH or VO Zone on the Flood Insurance Rate Map (FIRM) and as to which the base flood depths range from one to three feet, a clearly defined channel does not exist, the path of flooding is unpredictable and indeterminate, and velocity flow may be evident.

C. AREA OF SPECIAL FLOOD HAZARD. See "Special flood hazard area".

D. BASE FLOOD or 100 YEAR FLOOD. A flood having a one percent (1%) chance of being equalled or exceeded in any given year.

E. BASEMENT. An area of a building having its floor subgrade (below ground level) on all sides.

F. BREAKAWAY WALLS. Any type of wall, whether solid or lattice, and whether constructed of concrete, masonry, wood, metal, plastic or any other suitable building material which (i) is not part of the structural support of the building; (ii) is designed to break away under abnormally high tides or wave action without causing any damage to the structural integrity of the building or to any buildings to which they might be carried by flood waters; (iii) has a safe design loading resistance of not less than ten and no more than twenty pounds per square foot; and (iv) has been certified for use in the building by a registered engineer or architect and meets the following standards:

1. Breakaway wall collapse will result from a water load less than that which would occur during the base flood; and

2. The elevated portion of the building will not incur any structural damage due to the effects of wind and water loads acting simultaneously in the event of the base flood.

G. COASTAL HIGH HAZARD AREA. An area subject to high velocity waters, including coastal and tidal inundation or tsunamis and designated on a Flood Insurance Rate Map (FIRM) as Zone V1-V30, Ve or V.

H. DEVELOPMENT. Any man-made change to improved or unimproved real property, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations.

I. FLOOD or FLOODING. A general and temporary condition of partial or complete inundation of normally dry land areas from:

1. The overflow of flood waters;
2. The unusual and rapid accumulation or runoff of surface waters from any source; or
3. The collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as flash flood or an abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding as defined in this definition.

J. FLOOD BOUNDARY AND FLOODWAY MAP. The official map on which the Federal Emergency Management Agency or Federal Insurance Administration has delineated both the areas of flood hazard and the floodway.

K. FLOOD INSURANCE RATE MAP (FIRM). An official map on which the Federal Emergency Management Agency or Federal Insurance Administration has delineated both the areas of special flood hazards and the risk premium zones applicable to the community.

L. FLOOD INSURANCE STUDY. An official report provided by the Federal Insurance Administration that includes flood profiles, the FIRM, the Flood Boundary and Floodway Map, and the water surface elevation of the base flood.

M. FLOODPLAIN or FLOOD-PRONE AREA. Any land area susceptible to being inundated by water from any source (see definition of "flooding").

N. FLOODPLAIN MANAGEMENT. The operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to, emergency preparedness plans, flood control works and floodplain management regulations.

O. FLOODPLAIN MANAGEMENT REGULATIONS. Zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances (such as floodplain ordinances, grading ordinances and erosion control ordinances) and other applications of police power. The term describes such state or local regulations in any combination thereof, which provide standards for the purpose of flood damage prevention and reduction.

P. FLOODPROOFING. Any combination of structural and nonstructural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents.

Q. FLOODWAY or REGULATORY FLOODWAY. The channel of a river or other watercourse and the adjacent land areas that must be preserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one (1) foot.

R. FUNCTIONALLY DEPENDENT USE. A use which cannot perform its intended purpose unless it is located or carried out in close proximity to water. The term includes vessel docking facilities, port facilities that are necessary for the loading and unloading of cargo or passengers, and ship building and ship repair facilities, and does not include long-term storage or related manufacturing facilities.

S. HIGHEST ADJACENT GRADE. The highest undisturbed elevation of the ground surface prior to construction next to the proposed walls of a structure.

T. LOWEST FLOOR. The lowest floor of the lowest enclosed area (including basement). An unfinished or flood resistant enclosure, usable solely for parking of vehicles, building access or storage in an area other than a basement area is not considered a building's lowest floor, provided, that such enclosure is not built so as to render the structure in violation of the applicable non-elevation design requirements of this chapter.

U. MANUFACTURED HOME. A structure, transportable in one or more sections, which is designed for use with or without a permanent foundation when connected to the required utilities. For floodplain management purposes, the term "manufactured home" also includes park trailers, travel trailers and other similar vehicles placed on a site for greater than 180 consecutive days.

V. MANUFACTURED HOME PARK or SUBDIVISION. A parcel (or contiguous parcels) of land divided into two or more manufactured home lots for sale or rent.

W. MEAN SEA LEVEL. The National Geodetic Vertical Datum (NGVD) of 1929 or other datum, to which base flood elevations shown on a community's Flood Insurance Rate Map are referenced.

X. NEW CONSTRUCTION. A structure for which the "start of construction" occurred on or after the effective date of this Chapter, or any applicable amendment thereto.

Y. ONE HUNDRED YEAR FLOOD. See "base flood".

Z. PERSON. An individual, firm, partnership, association or corporation, or agent of the foregoing, or this state or its agencies or political subdivisions.

AA. REMEDY A VIOLATION. To bring a structure or other development into compliance with state or local floodplain management regulations, or, if this is not possible, to reduce the impacts of its noncompliance by various means, including but not limited to, protecting the structure or other affected development from flood damages, implementing the enforcement provisions of the ordinance or otherwise deterring future similar violations, or reducing federal financial exposure with regard to the structure or other development.

BB. RIVERINE. Relating to, formed by, or resembling a river (including tributaries), stream, or brook.

CC. SAND DUNES. Naturally occurring accumulations of sand in ridges or mounds landward of the beach.

DD. SPECIAL FLOOD HAZARD AREA (SFHA). An area having special flood or coastal high hazards, and shown on an FHBM or FIRM as Zone A, AO, A1-30, AE, A99, AH, VO, V1-V30, VE or V.

EE. START OF CONSTRUCTION. The date the building permit was issued, provided the actual start of construction was within 180 days of the permit date. The actual start means either the first placement of permanent construction of a structure on a site, such as the pouring of slab or footings, the installation of piles, the construction of columns, or any work beyond the stage of excavation; or the placement of a manufactured home on a foundation pursuant to a valid building permit. Permanent construction does not include land preparation, such as clearing, grading, and filling, nor does it include the installation of streets or walkways; nor does it include excavation for a basement, footings, piers, or foundations or the erection of temporary forms; nor does it include the installation on the property of accessory buildings, such as garages or sheds not occupied as dwelling units or not as part of the main structure.

FF. STRUCTURE. A walled and roofed building, including a gas or liquid storage tank that is principally above ground, as well as a manufactured home.

GG. SUBSTANTIAL IMPROVEMENT. Any repair, reconstruction, or improvement of a structure within any twenty four (24) month period, the cost of which equals or exceed fifty percent (50%) of the market value of the structure either before the improvement or repair is started or, if the structure has been damaged and is being restored, before the damage occurred. For the purposes of this definition, "substantial improvement" is considered to occur when the first alteration of any wall, ceiling, floor, or other structural part of the building commences, whether or not that alteration affects the external dimensions of the structure. The term does not, however, include either:

1. Any project for improvement of a structure to comply with existing state or local health, sanitary, or safety code specifications which are solely necessary to assure safe living conditions, or

2. Any alteration of a structure listed on the National Register of Historic Places or a State Inventory of Historic Places.

HH. VARIANCE. A grant of relief from the requirements of this Chapter which permits construction in a manner that would otherwise be prohibited by this Chapter.

II. VIOLATION. The failure of a structure or other development to be in full compliance with this Chapter. A structure or other development without the elevation certificate, other certifications, or other evidence of compliance required in this Chapter is presumed to be in violation until such time as that documentation is provided. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.050 Lands to Which This Chapter Applies.

This chapter shall apply to all areas of special flood hazards within the City of Santa Barbara. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.060 Basis for Establishing the Areas of Special Flood Hazard.

"The Flood Insurance Study for The City of Santa Barbara", dated May 4, 1978 and revised October 15, 1985, and December 3, 1991 and all subsequent revisions by the U. S. Federal Emergency Management Agency with accompanying Flood Insurance Rate Maps is hereby adopted by reference and declared to be a part of this Chapter. Copies of the Flood Insurance Study and maps referred to therein, shall be maintained on file at 630 Garden Street, Santa Barbara, California, and at the Office of the City Clerk, City Hall, Santa Barbara, California. The Flood Insurance Study establishes the areas of special flood hazard identified by the Federal Emergency Management Agency or the Federal Insurance Administration. These areas are the minimum area of applicability of this Chapter; their boundaries may be changed, or new areas designated by the City Council following a recommendation thereon by the Chief of Building and Zoning. (Ord. 4731, 1991; Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.070 Compliance.

No structure or land shall hereafter be constructed, located, extended, converted, or altered without full compliance with the terms of this Chapter and other applicable regulations. Violations of the provisions of this Chapter by failure to comply with any of its requirements (including violations of conditions and safeguards established in connection with conditions) shall constitute a misdemeanor. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.080 Abrogation and Greater Restrictions.

This Chapter is not intended to repeal, abrogate, or impair any existing easements, covenants, or deed restrictions. However, where this Chapter and another ordinance, easement, covenant, or deed restriction conflict or overlap, whichever imposes the more stringent restrictions shall prevail. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.090 Interpretation.

In the interpretation and application of this Chapter, all provisions shall be considered as minimum requirements, liberally construed in favor of the governing body, and, deemed neither to limit nor repeal any other powers granted under state statutes. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.100 Warning and Disclaimer of Liability.

The degree of flood protection required by this Chapter is considered reasonable for regulatory purposes and is based on scientific and engineering considerations. Larger floods can and will occur on rare occasions. Flood heights may be increased by man-made or natural causes. This Chapter does not imply that land outside the areas of special flood hazards or uses permitted within such areas will be free from flooding or flood damages. This Chapter shall not create liability on the part of the City of Santa Barbara, any officer or employee thereof, or the Federal Insurance Administration, for any flood damages that result from reliance on this Chapter or any administrative decision made thereunder. (Ord.4522, 1988; Ord. 3972, 1978.)

22.24.110 Establishment of Development Permit.

A development permit shall be obtained before construction or development begins within any area of special flood hazard. Application for a development permit shall be made on forms furnished by the Chief of Building and Zoning and may include, but not be limited to: plans in duplicate drawn to scale showing the nature, location, dimensions, and elevations of the area in question; existing or proposed structures, fill, storage of materials, and drainage facilities; and the location of the foregoing. The following information is required on an application:

A. Elevation in relation to mean sea level, of the lowest floor (including basement) of all structures; in Zone AO or VO, elevation of highest adjacent grade and proposed elevation of lowest floor of all structures.

B. Elevation in relation to mean sea level to which any structure has been will be floodproofed;

C. All certifications required by Sections 22.24.130F and 22.24.160; and

D. Description of the extent to which any watercourse will be altered or relocated as a result of proposed development. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.120 Designation of the Chief of Building and Zoning.

The Chief of Building and Zoning is hereby appointed to administer and implement this Chapter by granting or denying development permit applications in accordance with its provisions. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.130 Duties and Responsibilities of the Chief of Building and Zoning.

Duties of the Chief of Building and Zoning shall include, but not be limited to:

A. Review of all development permits to determine that the permit requirements of this Chapter have been satisfied.

B. Review of all development permits to determine that all necessary permits have been obtained from those federal, state or local governmental agencies from which prior approval is required.

C. Review of all development permits to determine that the site is reasonably safe from flooding and will not result in flood elevations increasing more than one foot.

D. Review of all development permits to determine if the proposed development adversely affects the flood carrying capacity of areas where base flood elevations have been determined but a floodway has not been designated. For purposes of this Chapter, "adversely affects" means that the cumulative effect of the proposed development when combined with all other existing and anticipated development will not increase the water surface elevation of the base flood more than one foot at any point.

E. When base flood elevation data in accordance with Section 22.24.060 is unavailable, the Chief of Building and Zoning shall obtain, review, and reasonably utilize any base flood elevation and floodway data available from a federal, state or other source, in order to administer Section 22.24.160 pertaining to specific standards for residential and nonresidential construction.

F. Maintain for public inspection all records pertaining to the provisions of this Chapter, including:

1. The certification required in Section 2.24.160.C.1 (floor elevations);
2. The certification required in Section 22.24.160.C.2 (elevations in areas of shallow flooding);
3. The certification required in Section 22.24.160.C.3 (elevation or floodproofing of nonresidential structures);
4. The certification required in Section 22.24.160.C.3 (wet floodproofing standard);
5. The certified elevation required in Section 22.24.160.E.2 (subdivision standards);
6. The certification required in Section 22.24.180.A (floodway encroachments); and
7. The information required in Section 22.24.170 (coastal construction standards).

G. Notify adjacent communities, the Santa Barbara County Flood Control and Water Conservation District, and the California Department of Water Resources prior to any alteration or relocation of a watercourse, and submit evidence of such notification to the Federal Insurance Administration. Require that the flood carrying capacity of the altered or relocated portion of the watercourse is maintained.

H. Make interpretations as to the exact location of the boundaries of the areas of special flood hazards, (for example, where there appears to be a conflict between a mapped boundary and actual field conditions). The persons contesting the location of the boundary shall be given a reasonable opportunity to appeal the interpretation as provided in Section 22.24.140.

I. Take action to remedy violations of this Chapter as specified in Section 22.24.070. (Ord. 4539, 1988; Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.140 Variance and Appeal Procedure.

A. The Planning Commission of the City of Santa Barbara shall hear and decide appeals and requests for variances from the requirements of this Chapter.

B. The Planning Commission shall hear and decide appeals when it is alleged there is an error in any requirement, decision, or determination made by the Chief of Building and Zoning in the enforcement or administration of this Chapter.

C. The applicant or any interested person may appeal the decision of the Planning Commission to the City Council in accordance with the procedures provided in Section 28.92.025.1 of this Code.

D. In reviewing such application, the Planning Commission shall consider all technical evaluations, all relevant factors, standards specified in other sections of this Chapter, and each of the following:

1. The danger that materials may be swept onto other lands to the injury of others.
2. The danger to life and property due to flooding or erosion damage.
3. The susceptibility of the proposed facility and its contents to flood damage and the effect of such damage on the individual owner.
4. The importance of the services provided by the proposed facility to the community.
5. The necessity to the facility of a waterfront location, where applicable.
6. The availability of alternative locations for the proposed use which are not subject to flooding or erosion damage.
7. The compatibility of the proposed use with existing and anticipated development.
8. The relationship of the proposed use to the General Plan and Flood Plain Management Program for that area.
9. The safety of access to the property in times of flood for ordinary and emergency vehicles.
10. The expected heights, velocity, duration, rate of rise, and sediment transport of the flood waters and the effects of wave action, if applicable, expected at the site.

11. The costs of providing governmental services during and after flood conditions, including maintenance and repair of public utilities and facilities such as sewer, gas, electrical, and water systems, and streets and bridges.

E. Variances may be issued for new construction and substantial improvements to be erected on a lot of one-half acre or less in size contiguous to and surrounded by lots with existing structures constructed below the base flood level, providing items identified in Paragraph D have been fully considered. As the lot size increases beyond the one-half acre, the technical justification required for issuing the variance increases.

F. Upon consideration of the factors identified in Paragraph D and the purposes of this Chapter, the Planning Commission may attach such conditions to the granting of variances as it deems necessary to further the purposes of this ordinance.

G. The Chief of Building and Zoning shall maintain the records of all appeal actions and report any variances to the Federal Insurance Administration upon request. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.150 Conditions for Variances.

A. Variances may be issued for new construction and substantial improvements and for other development necessary for the conduct of a functionally dependent use, provided the provisions of Section 22.24.140D are satisfied and that the structure or other development is protected by methods that minimize flood damage during the base flood and create no additional threats to public safety.

B. Variances may be issued for the reconstruction, rehabilitation or restoration of structures listed on the National Register of Historic Places or the State Inventory of Historic Places, without regard to the procedures set forth in the remainder of this section.

C. Variances shall not be issued within any designated floodway if any increase in flood levels during the base flood discharge would result.

D. Variances shall only be issued upon a determination that the variance is the minimum necessary, considering the flood hazard, to afford relief.

E. Variances shall only be issued upon:

1. A determination that failure to grant the variance would result in exceptional hardship to the applicant; and

2. A determination that the granting of a variance will not result in increased flood heights, additional threats to public safety, extraordinary public expense, create nuisances, cause fraud on or victimization of the public as identified in Section 22.24.140.D, or conflict with existing local laws or ordinances.

F. An applicant to whom a variance is granted shall be given written notice that the structure will be permitted to be built with a lowest floor elevation below the base elevation and that the cost of flood insurance will be commensurate with the increased risk resulting from the reduced lowest floor elevation. A copy of the notice shall be recorded by the Chief of Building and Zoning in the office of the Santa Barbara County Recorder in a manner so that it appears in the chain of title of the affected parcel of land. (Ord. 4522, 1988, Ord. 3972, 1978.)

22.24.160. General Standards for Flood Hazard Reduction.

In all areas of special flood hazards the following standards shall apply:

A. Anchoring

1. All new construction and substantial improvements shall be anchored to prevent flotation, collapse or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy.

2. All manufactured homes shall be securely anchored to a permanent foundation system to resist flotation, collapse, or lateral movement, and shall be elevated so that the lowest floor is at or above the base flood elevation, unless a higher elevation is required by the Chief of Building and Zoning.

B. Construction Material and Methods.

1. All new construction and substantial improvements shall be constructed with materials and utility equipment resistant to flood damage.

2. All new construction and substantial improvements shall be constructed using methods and practices that minimize flood damage.

3. All new construction and substantial improvements shall be constructed with electrical, heating, ventilation, plumbing and air conditioning equipment and other service facilities that are designed and located so as to prevent water from entering or accumulating within the components during conditions of flooding.

4. Require within Zones AH, AO or VO, adequate drainage paths around structures on slopes to guide flood waters around and away from proposed structures.

C. Elevation and Floodproofing.

1. New construction and substantial improvement of any structure shall have the lowest floor, including basement, elevated to or above the base flood elevation, unless a higher elevation is required by the Chief of Building and Zoning. Nonresidential structures may meet the standards in subsection 3. below. Upon the completion of the structure the elevation of the lowest floor, including basement, shall be certified by a registered professional engineer or surveyor, or verified by the building inspector to be properly elevated. Such certification or verification shall be provided to the Chief of Building and Zoning.

2. New construction and substantial improvement of any structure in Zone AO or VO shall have the lowest floor, including basement, elevated at least as high as the depth number specified in feet on the FIRM, or at least two feet above the highest adjacent grade if no depth number is specified. Nonresidential structures may meet the standards in subsection 3. below. Upon the completion of the structure the elevation of the lowest floor including basement shall be certified by a registered professional engineer or surveyor, or verified by the building inspector to be properly elevated. Such certification or verification shall be provided to the Chief of Building and Zoning.

3. Nonresidential construction shall either be elevated in conformance with subsection 2. above or, together with attendant utility and sanitary facilities, shall:

a. Be floodproofed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water;

b. Have structural components capable of resisting hydrostatic and hydrodynamic loads and effects for buoyancy; and

c. Be certified by a registered professional engineer or architect that the standards of this subsection are satisfied. Such certifications shall be provided to the Chief of Building and Zoning.

4. Require, for all new construction and substantial improvements, that fully enclosed areas below the lowest floor that are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria:

a. A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one foot above grade. Openings may be equipped with screens, louvers, valves or other coverings or devices provided that they permit the automatic entry and exit of floodwaters; or

b. Be certified to comply with a local floodproofing standard approved by the Federal Insurance Administration.

5. Manufactured homes shall also meet the standards in subsection A.2. above.

D. Utilities.

1. All new and replacement water supply and sanitary sewage systems shall be designed to minimize or eliminate infiltration of flood waters into the system and discharge from systems into flood waters.

2. On-site waste disposal systems shall be located to avoid impairment to them or contamination from them during flooding.

E. Subdivision Proposals.

1. All preliminary subdivision proposals shall identify the flood hazard area and the elevation of the base flood.

2. All final subdivision plans shall provide the elevation of proposed structure(s) and pads. If the site is filled above the base flood, the final pad elevation shall be certified by a registered professional engineer or surveyor and provided to the Chief of Building and Zoning.

3. All subdivision proposals shall be consistent with the need to minimize flood damage.

4. All subdivision proposals shall have public utilities and facilities such as sewer, gas, electrical, and water systems located and constructed to minimize flood damage.

5. All subdivision proposals shall have adequate drainage provided to reduce exposure to flood damage. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.170 Coastal High Hazard Areas.

Section 22.24.060, within coastal high hazard areas established pursuant to
the following standards shall apply:

A. All new construction and substantial improvements shall be elevated on adequately anchored pilings or columns and securely anchored to such pilings or columns so that the lowest horizontal portion of the structural members of the lowest floor (excluding the pilings or columns) is elevated to or above the base flood elevation, unless a higher elevation is required by the Chief of Building and Zoning.

B. All new construction and substantial improvements shall have the space below the lowest floor free of obstructions or constructed with breakaway walls. Such temporarily enclosed space shall not be used for human habitation or storage.

C. Fill shall not be used for structural support of buildings.

D. Man-made alteration of sand dunes which would increase potential flood damage is prohibited.

E. The Chief of Building and Zoning shall obtain and maintain the following records:

1. Certification by a registered engineer or architect that a proposed structure complies with subsection A above.

2. The elevation (in relation to mean sea level) of the bottom of the lowest structural member of the lowest floor (excluding pilings or columns) of all new and substantially improved structures, and whether such structures contain a basement. (Ord. 4522, 1988; Ord. 3972, 1978.)

22.24.180. Floodways.

Since the floodway is an extremely hazardous area due to the velocity of flood waters which carry debris, potential projectiles, and erosion potential, the following provisions apply to floodways.

A. No encroachments, including fill, new construction, substantial improvements, and other development are permitted unless a registered professional engineer or architect certifies that the development will not result in any increase in flood levels during the occurrence of the base flood discharge.

B. If subsection A above is satisfied, all new construction and substantial improvements shall comply with all applicable flood hazard reduction provisions of Sections 22.24.160 and 22.24.170.

C. No mobile homes may be placed in any floodway, except in a mobile home park or mobile home subdivision established prior to the effective date of this Chapter. (Ord. 4522, 1988; Ord. 3972, 1978.)

APPENDIX 3

28.87.250 Development Along Creeks.

1. Legislative Intent. The purpose of this Section is to provide controls on development adjacent to the bed of Mission Creek within the City of Santa Barbara. These controls are necessary:

a. to prevent undue damage or destruction of developments by flood waters;

b. to prevent development on one parcel from causing undue detrimental impact on adjacent or downstream properties in the event of flood waters;

c. to protect the public health, safety and welfare.

2. Limitation on Development. No person may construct, build, or place a development within the area described in Subsection 28.87.250.3 unless said development has been previously approved as provided in Subsection 28.87.250.5.

3. Land Area Subject to Limitation. The limitations of this Section shall apply to all land within the banks and located within twenty-five (25) feet of the top of either bank of Mission Creek within the City of Santa Barbara.

"Top of bank" means the line formed by the intersection of the general plane of the sloping side of the watercourse with the general plane of the upper generally level ground along the watercourse; or, if the existing sloping side of the watercourse is steeper than the angle of repose (critical slope) of the soil or geologic structure involved, "top of bank" shall mean the intersection of a plane beginning at the toe of the bank and sloping at the angle of repose with the generally level ground along the watercourse. The angle of repose is assumed to be 1.5 (horizontal) : 1 (vertical) unless otherwise specified by a geologist or soils engineer with knowledge of the soil or geologic structure involved.

"Toe of bank" means the line formed by the intersection of the general plane of the sloping side of the watercourse with the general plane of the bed of the watercourse.

4. Development Defined. Development, for the purposes of this Section, shall include any building or structure requiring a building permit; the construction or placement of a fence, wall, retaining wall, steps, deck (wood, rock, or concrete), or walkway; any grading; or, the relocation or removal of stones or other surface which forms a natural creek channel.

5. Approval Required. Prior to construction of a development in the area described in Subsection 28.87.250.3, the property owner shall obtain approvals as follow:

a. Any development subject to the requirement for a building permit shall be reviewed and approved by the Chief of Building and Zoning or the Planning Commission on appeal prior to the issuance of a building permit.

b. Any development not requiring a building permit shall be reviewed and approved by the Chief of Building and Zoning or his designated representative or the Planning Commission on appeal. A description of the development shall be submitted showing the use of intended development, its location, size and manner of construction.

6. Development Standards. No development in the area subject to this Section shall be approved unless it is found that it will be consistent with the purposes set forth in Subsection 28.87.250.1.

a. The Chief of Building and Zoning or the Planning Commission on appeal shall consider the following in determining whether the development is consistent with Subsection 28.87.250.1:

(1) That the proposed new development will not significantly reduce existing floodways, re-align stream beds or otherwise adversely affect other properties by increasing stream velocities or depths, or by diverting the flow, and that the proposed new development will be reasonably safe from flow-related erosion and will not cause flow-related erosion hazards or otherwise aggravate existing flow-related erosion hazards.

(2) That proposed additions, alterations or improvements comply with Subsection a(1) above.

(3) That proposed reconstruction of structures damaged by fire, flood or other calamities will comply with Subsection a(1) above, or be less nonconforming than the original structure and will not adversely affect other properties.

(4) The report, if any, of a qualified soils engineer or geologist and the recommendations of the Santa Barbara County Flood Control and Water Conservation District.

(5) After review of that report, whether denial of approval would cause severe hardship or prohibit the reasonable development and use of the property.

b. The Chief of Building and Zoning, or the Planning Commission on appeal may consider the following factors as mitigating possible hazards which might otherwise result from such development:

(1) Where the development is located on a bank of the creek which is sufficiently higher than the opposite bank to place the development outside a flood hazard area.

(2) Where the creek bed adjacent to the development is sufficiently wide or the creek bank slope sufficiently gradual that the probability of flood hazard is reduced.

(3) Where approved erosion or flood control facilities or devices have been installed in the creek bed adjacent to the development.

(4) Where the ground level floor of the development is not used for human occupancy and has no solid walls.

(5) Where the development is set on pilings so that the first occupied floor lies above the 100-year flood level, and such pilings are designed to minimize turbulence.

c. The Chief of Building and Zoning or the Planning Commission on appeal may allow development into required yards if he makes the finding that the encroachment would not be necessary except for the development controls required by this section and that the modification of the required yard is necessary to secure an appropriate improvement on a lot, to prevent unreasonable hardship or to promote uniformity of improvement.

7. Procedures. The following procedures shall apply to developments in the area defined in Subsection 28.87.250.3:

a. All applicants shall receive an environmental assessment.

b. All applications shall be referred to the Santa Barbara County Flood Control and Water Conservation District and the City Public Works Department for review and comment.

c. Upon completion of the above review and comment, the proposed development shall be reviewed by the Chief of Building and Zoning as provided in Subsection 28.87.250.5. The Chief of Building and Zoning shall give the applicant and any other person requesting to be heard, an opportunity to submit oral and/or written comments to him prior to his decision. The Chief of Building and Zoning shall send by mail notice of his decision to the applicant. The decision of the Chief of Building and Zoning shall be final unless appealed by the applicant or any interested person to the Planning Commission within ten (10) days by the filing of a written appeal with the Department of Community Development. The Department of Community Development shall schedule the matter for a hearing by the Planning Commission and shall mail the applicant and any interested person requesting notice written notice of the hearing ten (10) days before the hearing. The decision of the Planning Commission shall be final. (Ord. 4056, 1980.)

APPENDIX 4

EARTHQUAKE SAFETY PROCEDURES

BEFORE AN EARTHQUAKE

1. Potential earthquake hazards in the home should be removed or corrected. Top-heavy objects and furniture, such as bookcases and storage cabinets, should be fastened to the wall and the largest and heaviest objects placed on lower shelves. Water heaters and other appliances should be firmly bolted down, and flexible connections should be used whenever possible.

2. Supplies of food and water, flashlight, a first-aid kit, and a battery-powered radio should be set aside for use in emergencies. Of course, this is advisable for other types of emergencies, as well as for earthquakes.

3. One or more members of the family should have a knowledge of first aid procedures because medical facilities nearly always are overloaded during an emergency or disaster, or may themselves be damaged beyond use.

4. All responsible family members should know what to do to avoid injury and panic. They should know how to turn off the electricity, water, and gas; they should know the locations of the main switch and valves. This is particularly important for teenagers who are likely to be alone with smaller children.

5. It is most important for a resident of California to be aware that this is "earthquake country" and that earthquakes are most likely to occur again where they have occurred before. Building codes that require earthquake-resistant construction should be vigorously supported and, when enacted into law, should be rigorously enforced. If effective building codes and grading ordinances do not exist in your community, support their enactment.

DURING AN EARTHQUAKE

1. The most important thing to do during an earthquake is to remain calm. If you can do so, you are less likely to be injured. If you are calm, those around you will have a greater tendency to stay calm, too. Make no moves or take no action without thinking about the possible consequences. Motion during an earthquake is not constant; commonly, there are a few seconds between tremors.

2. If you are inside a building, stand in a strong doorway or get under a desk, table, or bed. Watch for falling plaster, bricks, light fixtures, and other objects. Stay away from tall furniture, such as china cabinets, bookcases, and shelves. Stay away from windows, mirrors and chimneys. In tall buildings, it is best to get under a desk if it is securely fastened to the floor, and to stay away from windows or glass partitions.

3. Do not rush outside. Stairways and exits may be broken or may become jammed with people. Power for elevators and escalators may have failed. Many of the 115 persons who perished in Long Beach and Compton in 1933 ran outside only to be killed by falling debris and collapsing chimneys. If you are in a crowded place such as a theater, athletic stadium, or store, do not rush for an exit because many others will do the same thing. If you must leave a building,

choose your exit with care and, when going out, take care to avoid falling debris and collapsing walls or chimneys.

4. If you are outside when an earthquake strikes, try to stay away from high buildings, walls, power poles, lamp posts, or other structures that may fall. Falling or fallen electrical power lines must be avoided. If possible, go to an open area away from all hazards, but do not run through the streets. If you are in an automobile, stop in the safest possible place, which, of course, would be an open area, and remain in the car.

AFTER AN EARTHQUAKE

1. After an earthquake, the most important thing to do is to check for injuries in your family and in the neighborhood. Seriously injured persons should not be moved unless they are in immediate danger of further injury. First aid should be administered, but only by someone who is qualified.

2. Check for fires and fire hazards. If damage has been severe, water lines to hydrants, telephone lines, and fire alarm systems may have been broken; contacting the fire department may be difficult. Some cities, such as San Francisco, have auxiliary water systems and large cisterns in addition to the regular system that supplies water to fire hydrants. Swimming pools, creeks, lakes, and fish ponds are possible emergency sources of water for firefighting.

3. Utility lines to your house - gas, water and electricity - and appliances should be checked for damage. If there are gas leaks, shut off the main valve which is usually at the gas meter. Do not use matches, lighters, or open-flame appliances until you are sure there are no gas leaks. Do not use electrical switches or appliances if there are gas leaks, because they give off sparks which could ignite the gas. Shut off the electrical power if there is damage to the wiring; the main switch usually is in or next to the main fuse or circuit breaker box. Spilled flammable fluids, medicines, drugs, and other harmful substances should be cleaned up as soon as possible.

4. Water lines may be damaged to such an extent that the water may be off. Emergency drinking water can be obtained from water heaters, toilet tanks, canned fruits and vegetables, and melted ice cubes. Toilets should not be flushed until both the incoming water lines and outgoing sewer lines have been checked to see if they are open. If electrical power is off for any length of time, plan to use the foods in your refrigerator and freezer first before they are spoiled. Canned and dried foods should be saved until last.

5. There may be much shattered glass and other debris in the area, so it is advisable to wear shoes or boots and a hard hat if you own one. Broken glass may get into foods and drinks. Liquids can be either strained through a clean cloth such as a handkerchief or decanter. Fireplaces, portable stoves, or barbecues can be used for emergency cooking, but the fireplace chimney should be carefully checked for cracks and other damages before being used. In checking the chimney for damage, it should be approached cautiously, because weakened chimneys may collapse with the slightest of aftershocks. Particular checks should be made of the roof line and in the attic because unnoticed

damage can lead to a fire. Closets and other storage areas should be checked for objects that have been dislodged or have fallen, but the doors should be opened carefully because of objects that may have fallen against them.

6. Do not use the telephone unless there is a genuine emergency. Emergencies and damage reports, alerts, and other information can be obtained by turning on your radio. Do not go sightseeing; keep the streets open for the passage of emergency vehicles and equipment. Do not speculate or repeat the speculations of others - this is how rumors start.

7. Stay away from beaches and other waterfront areas where seismic sea waves (tsunamis), sometimes called "tidal waves," could strike. Again, your radio is the best source of information concerning the likelihood that a seismic sea wave will occur. Also stay away from steep landslide-prone areas if possible, because aftershocks may trigger a landslide or avalanche, especially if there has been a lot of rain and the ground is nearly saturated. Also stay away from earthquake-damaged structures. Additional earthquake shocks known as "aftershocks" normally occur after the main shock, sometimes over a period of several months. These are usually smaller than the main shock, but they can cause damage too, particularly to damaged and already weakened structures.

8. Parents should stay with young children who may suffer psychological trauma if parents are absent during the occurrence of aftershocks.

9. Cooperate with all public safety and relief organizations. Do not go into damaged areas unless authorized; you are subject to arrest if you get in the way of, or otherwise hinder, rescue operations. Martial law has been declared in a number of earthquake disasters. In the 1906 disaster in San Francisco, several looters were shot.

10. Send information about the earthquake to the Seismological Field Survey to help earth scientists understand earthquakes better.

APPENDIX 5

GLOSSARY

Active Fault - One that has moved in recent geologic time and which is likely to move again in the relatively near future. Definitions for planning purposes extend on the order of movement in the last 11,000 years.

Alluvium - A general term for all detrital deposits resulting from the operations of modern rivers, thus including the sediments laid down in river beds, flood plains, lakes, fans at the foot of mountain slopes and estuaries.

Alluvial Fan - A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain or meets a slower stream. The fans generally form where streams issue from mountains upon the lowland.

Amplification - The increase in earthquake ground motion that may occur to the principal components of seismic waves as they enter and pass through different earth materials.

Aquifer - Stratum or a zone below the surface of the earth capable of producing water as from a well.

Attenuate - The decrease in amplitude of a wave or current with increasing distance from the source of transmission.

Bed - The smallest division of a stratified series, and marked by a more or less well-defined plane from its neighbors above and below.

Bedding Plane - In sedimentary rocks or stratified rocks, the division planes which separate the individual layers, beds, or strata.

Bedrock - Any solid rock underlying soil, sand, clay, etc.

Capable Fault - A term used by the Atomic Energy Commission to describe a fault that has moved "at or near the ground surface at least once in the past 35,000 years," or "more than once in the past 500,000 years."

Dip - The angle at which a stratum or any planar feature is inclined from the horizontal. The dip is at right angles to the strike.

Epicenter - That point on the Earth's surface which is directly above the true center of an earthquake (focus) which was the source of a given set of elastic waves.

Fanglomerate - A fanglomerate is composed of heterogeneous materials which were originally deposited in an alluvial fan but which since have been cemented into solid rock.

Fault - A fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture.

Fault Block - A mass bounded on at least two opposite sides by faults; it may be elevated or depressed relative to the adjoining region, or it may be elevated relative to the region on one side and depressed relative to that on the other.

Fault Zone - A fault, instead of being a single clean fracture, may be a zone hundreds or thousands of feet wide; the fault zone consists of numerous interlacing small faults.

Fracture - Breaks in rocks due to inverse folding or faulting.

Ground Response - A general term referring to the response of earth materials to the passage of earthquake vibration.

Holocene - Recent; that period of time (an epoch) since the last ice age. Generally considered to be the last 11,000 years.

Joint - Fracture in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred.

Magnitude - A quantity characteristic of the total energy released by an earthquake, as contrasted to "intensity", which describes its effects at a particular place. The Richter magnitude scale is related to the logarithm of an observed displacement on a calibrated instrument and its distance from the epicenter. Each step of one magnitude represents a 10-fold increase in observed shock wave amplitude and a 31.6 times increase in total energy released.

Outcrop - The exposure of bedrock or strata projecting through the overlying cover of detritus and soil.

Perched Groundwater - Groundwater separated from an underlying body of groundwater by unsaturated rock.

Scarp - A steep slope or cliff commonly associated with landslides or fault displacement.

Seismic - Pertaining to an earthquake or earth vibration including those that are artificially induced.

Shear - A mode of failure whereby two adjacent parts of a solid slide past one another parallel to the plane of contact. To subject a body to shear, similar to the displacement of the cards in a pack relative to one another.

Shear Strength - The internal resistance offered to shear stress. It is measured by the maximum shear stress, based on original area of cross section, that can be sustained without failure.

Slip Plane - Closely spaced surfaces along which different movement takes place in rock. Analogous to surfaces between a stack of playing cards.

Slough - A place of deep mud or mire.

Slump - The downward slipping of a mass of rock or unconsolidated material of any size, moving as a unit or as several subsidiary units, usually with backward rotation on a more or less horizontal axis parallel to the cliff or slope from which it descends.

Strike - The course or bearing of the outcrop on an inclined bed or structure on a level surface; the direction or bearing of a horizontal line in the plane of inclined stratum, joint, fault, or other structural plane. It is perpendicular to the direction of the dip.

Tectonic - Of, pertaining to, or designating the rock structure and external forms resulting from the deformation of the earth's crust. As applied to earthquakes, it is used to describe shocks not due to volcanic action or to collapse of caverns or landslides.

Weathering - The group of processes, such as the chemical action of air and rain water and of plants and bacteria and the mechanical action of changes of temperature, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil.

APPENDIX 6

NATIVE PLANTS FOR THE STABILIZATION OF SEACLIFFS

Scientific Name	Common Name
Adenostoma sparsifolium	Ribbon wood/Red shank
Adenostoma fascicalatum	Chamise/Grease weed
Atriplex lentiformis	Brewer Saltbush
Baccharis pliularis	Dwarf Chaparral Broom
Ceanothus oliganthus	Hairy Ceanuthus
Eriodictyon californicum	Yerba Santa
Eriodictyon trichocalyx	Hairy Yerba Santa
Eriogonum fasciculatum	California Buckwheat
Heteromeles arbutifolica	California Holly
Armeria maritima	Thrift
Pinus attenuata	Knobcone Pine
Pinus xattenuradiata	None
Pinus radiata	Monterey Pine
Coreopsis maritima	Tickweed
Cupressocyparis leylandii	Cypress
Arctostaphylos hookeri	Manzanita
Artemisia californica	Sage Brush
Ceanothus gloriosus	None
Cercocarpus betuloides	Mountain Mahogany
Coreopsis gigantea	Coreopsis
Encelia californica	Bush Sunflower
Eriogonum arborescens	Wild Buckwheat

Garrya elliptica	Silk-Tassel Bush
Isomeris arborea	Bladderpod
Lavatera assurgentifola	Tree Mallow
Lupinus arboreus	Tree (bush) Lupine
Rhamnus californica	Coffee Berry
Rhus integrifolia	Lemonade Berry
Rhus lavrina	Laurel Sumac
Rhus ovata	Sugar Bush
Dudleya pulverulenta	Live Forever

APPENDIX 7

	RELATIVE GEOLOGIC TIME				ATOMIC TIME Millions of Years	TIME OF APPEARANCE OF DIFFERENT FORMS OF LIFE
	Era	Period		Epoch		
Age of Mammals	Cenozoic	Quaternary		Holocene		
				Pleistocene	2-3	Ice age, evolution of man.
		Tertiary		Pliocene	12	Age of mammoths.
				Miocene	26	Spread of anthropoid apes.
				Oligocene	37-38	Origin of more modern families of mammals, grazing animals.
				Eocene	53-54	Origin of many modern families of mammals, giant mammals.
				Paleocene	65	Origin of most orders of mammals, early horses.
Age of Reptiles	Mesozoic	Cretaceous		Late Early	136	Appearance of flowering plants; extinction of dinosaurs at end; appearance of a few modern orders and families of mammals.
		Jurassic		Late Middle Early	190-195	Appearance of some modern genera of conifers; origin of mammals and birds; height of dinosaur evolution.
		Triassic		Late Middle Early	225	Dominance of mammal-like reptiles.
Age of Invertebrates	Paleozoic	Permian		Late Early	280	Appearance of modern insect orders.
		Carbon-iferous Systems	Pennsyl-vanian	Late Middle Early		Dominance of amphibians and of primitive tropical forests which formed coal; earliest reptiles.
			Missis-sippian	Late Early	345	Earliest amphibians.
		Devonian		Late Middle Early	395	Earliest seed plants; rise of bony fishes.
		Silurian		Late Middle Early	430-440	Earliest land plants.
		Ordovician		Late Middle Early	500	Earliest known vertebrates.
		Cambrian		Late Middle Early	570	Appearance of most phyla of invertebrates.
	Precambrian				3,600+	Origin of life; algae, worm burrows.

GEOLOGIC TIME SCALE Modified from G. Ledyard Stebbins, Processes of Organic Evolution, 1966, Prentice-Hall, Inc., Englewood Cliffs, New Jersey